NATURE

No. 4225 SATURDAY, OCTOBER 21, 1950 Vol. 166

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Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
Telegrams: Phusis Lesquare London

Advertisements only should be addressed to:
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone Number: Temple Bar 1942

The annual subscription rate is £4 10 0, payable in advance, Inland or Abroad

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EXPANSION OF TECHNICAL EDUCATION: NUMBERS AND QUALITY

IN its third annual report, issued last July, the Advisory Council on Scientific Policy emphasized that the maintenance and improvement of the position of British industry in the world would involve a continuing and growing demand for men of the highest scientific attainments, both on the technical and on the administrative side in industry. At the same time, it gave the full weight of its authority to the early establishment, in the university system of Great Britain, of one or more colleges of applied science, with suitable governing bodies of their own. In addition, the Parliamentary and Scientific Committee has followed up its earlier report (of 1947) on colleges of technology and technological man-power, with one on technical education and skilled man-power*. At the end of July, when Sir Henry Tizard was addressing the Committee, he both commended this report and referred to the observations on technological education of the Advisory Council on Scientific Policy. While he believes there should be more institutions of the highest class devoted to research and education in technology, he does not himself consider it necessary for them to be part of a university.. Afterwards, like Sir Harold Hartley, Sir Henry contributed to the debate on September 4 in Section L (Education) at the British Association meeting in Birmingham, which followed a paper by Sir Ewart Smith on the critical importance of higher technological education in relation to productivity, again urging the importance of a steady increase in the number, standard and prestige of technologists in all branches of industry, in the Dominions and Colonies as well as in Great Britain. In the course of the debate on defence in the House of Commons on September 13, Sir Ralph Glyn referred to the scarcity of technical man-power in the Services themselves, and said it is the result of an insufficient number of technical colleges and schools. In the later debate on the National Service Bill, Mr. McCorquodale made a like point in reference to the possible effect of the Bill on technical training.

Sir Ewart Smith, speaking at Birmingham, said he does not think that the means by which the higher technological education system is expanded, whether within the universities or by the creation of new institutes of technology, matters, so long as standards and balance are maintained. The increase in both the numbers and the quality of our resources in man-power in the field of applied science, in his view, should come by the natural growth and evolution of our existing institutions. His concern is rather with the quality of the education that is given: whatever the means adopted, the important thing is to ensure that the student is taught to think and to see his technology in its context, if not, indeed, as part of a general pattern of culture against which Dr. Eric James has suggested the teacher should see his subject.

* Parliamentary and Scientific Committee. Technical Education and Skilled Man-Power. Pp. 20. (London: Parliamentary and Scientific Committee, 1950.) 1s. 3d.

Whatever the means adopted, Sir Ewart said, the main increase in numbers is required in engineering and related technologies, which are the basis for the conversion of scientific knowledge to effective use in every type of industry. He believes that the difference in the relative numbers of those trained in applied science in Great Britain and the United States has been responsible for the difference in rate and efficiency with which scientific and technological knowledge is now being applied throughout industry in the two countries, and has also led to a lower overall standard of scientific approach and understanding in Great Britain in the whole field of management as affecting industrial affairs. Analysis of the main factors which determine industrial efficiency indicates that the rate at which productivity will increase depends primarily upon the evolution and application of new technical knowledge. This, in turn, depends upon the numbers and quality of the technologists available, upon the ability of industry to apply new knowledge by the expenditure of capital, and upon the willingness of the community to improve permanently future standards of life at the expense of some current saving in consumption.

The progress of industry, and therefore the economic position of the nation, mainly depend, in Sir Ewart's view, upon technological skill in application, and he is disturbed to find that, in spite of the doubling of the output of British universities in comparison with pre-war years, there has been no improvement in the proportion of those trained in applied science. The ratio of degrees in applied science to those in pure science in 1949 was no greater than in 1925. Sir Ewart recognizes that the output of applied scientists must to some extent be determined by the industrial demand; but he urged that industry should be encouraged to call for and use men who have had higher technological training, and that the rate of output should be steadily increased to match this growing and cumulative demand. There is a clear need in all walks of life, he said, for a proper proportion of men who have had an education to university standards, and particularly on the scientific side.

This emphasis on the aspect of quality in relation to the expansion of higher technological education may have led Sir Ewart's audience to overlook the full significance of his emphasis on the need for steadily continuing expansion. He himself, moreover, fully recognized that the fruits of such expansion can only be realized if the education of the population generally is such that the significance of scientific and technical factors in industry and in political and economic affairs is more clearly appreciated. That aspect was indeed fairly well explored in another discussion at the British Association meeting, at which Dr. Eric James took the place of Dr. J. B. Conant and spoke of the initiation of the arts student into scientific thought, including both method generally and elementary scientific work.

Nevertheless, an objective of increasing the overall national productivity of Great Britain by not less than 5 per cent per annum for many years to come implies, on Sir Ewart Smith's thesis, an immediate addition of nearly 1,500 per annum to the present 27,000 full-time students in pure science and technology, and a larger increment as the years pass. A continuing expansion on that scale in university and higher technological education must have other effects. Unless the increased number of technologists is secured to some extent by a reduction of the members graduating in pure science, the arts and other faculties, a point will be reached at which it will be necessary to consider more closely whether there are sufficient reserves of talent to profit adequately by training of a university standard at the public expense. The effect of such expansion on the supply of technicians and the general upgrading of the technical training of all the industrial manpower of Britain also require consideration. Sir Ewart Smith, in his paper, referred to the importance of this latter factor, though not to the necessity for striking a balance between the numbers of technicians and technologists.

The quantitative aspect of this problem is not given much consideration in the two reports from the Parliamentary and Scientific Committee, the first of which seems disposed to accept the output of 6,000–7,000 technologists and scientific workers envisaged in the report of the Percy Committee, and which apparently overlaps to some extent with the 3,303 applied scientists now coming from the universities —there are at present roughly 11,000 full-time students of technology in the universities. The reports are, indeed, concerned primarily with the question of quality and with the means by which this potential capacity can be most effectively utilized. In the earlier report, the Committee does not distinguish sufficiently between the training of technologists and the training of technicians; but in its second report, that distinction is drawn more clearly. It is recognized that the future scientific and technological development of the industries of Britain depends both on the ability of the technologists and those occupying posts of high responsibility, and also on the training and skill of the rank and file. The Committee refers, for example, to a report of the Medical Research Council published in 1944, which indicated that a serious dislocation in output accompanying changes in the type of product would have been avoided or reduced by more adequate training and consequent greater adaptability through greater familiarity with materials, confidence in the use of machinery and a knowledge of the part the worker's operation had played in the manufacture of the whole product. It quotes again the observation in the White Paper on Educational Reconstruction that, with the fading of the initial and natural advantages that gave Great Britain, almost for the asking, its pre-eminence in world manufacture and world markets, it will become more and more necessary to rely on the capacity, adaptability and quality of our industrial and commercial personnel.

The Committee points out that, in order to realize the full effect of increasing the number of technologists employed in industry, either in productivity or in the speedier translation of research results into industrial practice, it is essential for technologists to

have under their direction skilled men capable of erecting and running the new processes and of conferring with the technologist on problems which are bound to arise in the step from experimental to large-scale production. Skilled and well-trained men are less likely to resist changes essential to progress; rather they are frequently enthusiastic in bringing their work to a successful conclusion. Full industrial efficiency, in fact, requires personnel at all levels to show an intelligent appreciation of and response to the complex and rapidly changing techniques of modern production.

In these observations the Parliamentary and Scientific Committee shows awareness of a factor which was virtually ignored in the discussion which followed Sir Ewart Smith's paper at Birmingham. However much a more widespread and efficient system of technical education can do to dispel it, the recent dispute at the Wernett Mill, Oldham, is a reminder of a temper and outlook among trade unions which can offset any advantages in productivity to be gained by new machinery. The adjustment of working methods demands not only a higher standard of technical education, but even more a new outlook and attitude on the part of the workers. While the importance of the human factor in productivity was fully recognized in the discussion at Birmingham, not enough stress was laid on what is, in part at least, a psychological problem and one to which trade unions as well as educationists must turn if industrial productivity and efficiency are to be advanced, and with them standards of living raised, or even maintained.

WHY RUBBER IS 'RUBBER'

The Physics of Rubber Elasticity

By L. R. G. Treloar. (Monographs on the Physics and Chemistry of Materials.) Pp. vii + 256. (Oxford: Clarendon Press; London: Oxford University Press, 1949.) 21*s.* net.

IN these days one's first reaction to any new book is: Does it fill a real need? Of Dr. L. R. G. Treloar's book one can say at once that it does. Rubber is not only an important class of industrial material, but it also represents virtually a fourth state of matter—not solid, not liquid, not gas. Rubber, therefore, has a physics of its own, without an understanding of which its remarkable elastic properties can never be fully utilized. Fortunately, the subject has during the past fifteen years attracted many able physicists, who have built up an impressive structure of knowledge in this new field. Dr. Treloar's book, as the first comprehensive account of these developments, is thus of great importance, both to the rubber technologist and to the physicist desiring to investigate this intriguing subject further.

The fundamental concept of the new rubber physics is the statistical (or statistical-kinetic) origin of the force in stretched rubber. Whereas in an ordinary solid this force is due to deformation of inter-atomic bonds, in rubber it is due to rearrangement of the randomly kinked long-chain molecules into straighter forms with lower entropy. The first seven chapters of the book describe the gradual development and refinement of this theory and the comparison of its predictions with experimental data. The story is a fascinating one. It is perhaps not generally realized that the basic idea was put forward as early as 1855 by Kelvin, although further progress was not made until 1932–33. The story is not yet complete, and important further advances may be expected from the line of approach used by Mooney (1940) and developed by Rivlin, based on the stored-energy function rather than the force as the basic parameter, characterizing a deformation.

The second half of the book shows how various aspects of rubber deformation fit into the statistical theory or require its predictions to be modified. These are: photo-elastic properties (Chapter 8), neatly explained by the theory and yielding valuable data for its further development; crystallization in rubbers and its effects on mechanical properties (Chapters 9 and 10), the main effect being a departure from 'statistical' elasticity; stress relaxation and flow (Chapter 11), dynamic properties (Chapter 12), solution of problems involving large elastic strains (Chapter 13—which might better have followed Chapter 7). Chapters 10-12 show that these aspects of rubber deformation are far less understood than simple elastic deformation. Thus, no one yet seems to have explained why crystallization increases tensile strength (Chapter 10), and Chapters 11 and 12 clearly show the need to study flow and other technically important time-dependent deformations on lines analogous to those which have so successfully explained elastic deformation. Here, then, is a new challenge to the physicist.

Dr. Treloar's lucid style makes his book easy reading, and the fact that his own and his colleagues' researches form not a little of the subject-matter explains his mastery of it. The author's attempt to deal with the subject "in not too mathematical language" has succeeded admirably, and the readers for whom the book is intended—"physicists in universities and in government and industrial laboratories"—should have no difficulty whatever. The rubber technologist may regard the statement (p. 184) that "the carbon particles are evidently capable of taking over the function performed by the crystallites" as an over-simplification, or does it suggest a novel approach to explaining reinforcement? Errors seem remarkably few: neoprene is a *crystallizing* rubber (p. 191); "$1{\cdot}05 \times 10^{6}$" should be "$1{\cdot}1 \times 10^{12}$" on p. 195, line 8 from bottom.

The paper, printing and binding are fully worthy of the contents of a book on which both author and publisher are to be congratulated. J. R. SCOTT

A NEW MARINE NATURAL HISTORY

Natural History of Marine Animals

By G. E. MacGinitie and Nettie MacGinitie. Pp. xii + 473. (New York and London: McGraw-Hill Book Co., Inc., 1949.) 36*s.*

THIS volume is an important and refreshing addition to the literature on the interrelationships of marine animals in general, and it is all the more valuable in that most of the animals mentioned are from the relatively unknown littoral and offshore waters of the Pacific coast of North America. There are many points which will be of interest to marine biologists in Europe as, for example, the

striking predator/prey reaction between a starfish and a sand dollar urchin. In Great Britain the flight reaction initiated among groups of the small scallop (*Pecten opercularis*) by the physical and chemical presence of the common starfish is now fairly well known. Off the Californian coast the presence of another predatory starfish causes immediate burrowing of all the sand dollars in its vicinity.

The arrangement of the main subject-matter is systematic, enabling the reader to study the comparative ecology of a group rather than of a habitat. It is in these main sections that the authors have packed such a wealth of material on the general biology of the Pacific coast species. Much of this factual matter would appear to be derived from the writers' own observations, and it is perhaps unfortunate that the reader cannot readily distinguish the new from the old, owing to the lack of references.

The book contains excellent chapters on such general subjects as food, animal groupings and sense organs, and there is a stimulating discussion on growth-rate, a subject which is difficult to analyse in a population of marine animals, and upon which it is perhaps even more difficult to generalize. Records are given of some careful experiments on the growth of a colonial tunicate, from which the authors were able to calculate the frequency of division in a colony and the overall growth in unit time under varying conditions. The book ends with a chapter on the relation of higher vertebrates to shore conditions, and there are appendixes giving a short bibliography of general works, and an original analysis of animal phyla according to the types of habitat in which their representatives live.

The authors have written a stimulating book of value, packed with observations on the mode of life of marine animals, which shows that real natural history is still a very live subject.

H. G. VEVERS

SWEET ODOURS

Synthetic Perfumes

Their Chemistry and Preparation. By Dr. T. F. West, Dr. H. J. Strausz and Dr. D. H. R. Barton. Pp. viii+380. (London: Edward Arnold and Co., 1949.) 70*s*. net.

THE chemistry and preparative methods of the important perfumery synthetics are described systematically and factually in this book. It is one that should be a useful text-book for the manufacturer of perfumery chemicals, and a guide that will show the artist-perfumer what raw materials are available to him. It is a book in which the chemistry is uniformly sound and the nomenclature careful; in these respects it shows a considerable advance over some of its predecessors in the same field.

Some resolution is always needed to re-write material, but when an author is confronted with new information which disturbs what he has already written, he should not evade the task. Drs. T. F. West, H. J. Strausz and D. H. R. Barton have taken a rather different line in one or two instances. Their discussion of irone (pp. 178–185) was evidently written before October 1947, when both Ruzicka and Naves described its synthesis in *Helvetica Chimica Acta*. In fact, the "probable formula" of irone which is given on p. 178 of "Synthetic Perfumes" includes a 7-atom ring. The description of the synthesis and true constitution of irone is given on p. 336 in an addendum, which also includes a discussion of recent work on muscone and civetone. One cannot help thinking that it would have been far better to have incorporated this important new material in the body of the book, even at the cost of re-writing a part of it.

Perhaps it is because of the plurality of authorship that occasional cases of repetition are to be found; for example, the superiority of ethylvanillin to vanillin itself for use in the presence of methyl anthranilate, which is adequately described on p. 133, is repeated on p. 289.

Finally, it is to be deplored that technical books tend increasingly to cost more than most individuals can afford to pay for them. R. W. MONCRIEFF

THERMODYNAMICS FOR THE ADVANCED ENGINEERING STUDENT

Thermodynamics

Principles and Applications to Engineering. By Prof. Dr. Ernst Schmidt. Authorized translation from the third German edition, by J. Kestin. (Oxford Engineering Science Series.) Pp. xx+532. (Oxford: Clarendon Press; London: Oxford University Press, 1949.) 35*s*. net.

AT a first glance, this appears to be a book to be warmly welcomed, including, as it does, subjects of topical interest such as supersonic flow, jet-propulsion and even a paragraph on heavy water. However, on reflexion, doubts arise as to the possibility of covering the whole ground to the same high standard in a not too unwieldy volume, starting with yet another re-statement of elementary points. Investigation reveals that there is some selective treatment and omission of points which possible purchasers of the book might reasonably expect to find dealt with.

If the subject of fluid mechanics is to be admitted to a book on thermodynamics—and it seems inevitable nowadays—surely there are numerous problems connected with internal combustion engines coming under this heading; admittedly these are dealt with at some length in other books of this series. In Great Britain, Callendar's equation might be considered worthy of more attention than a short paragraph (and that somewhat derogatory). In fact, the basis of the steam tables (Keenan and Keyes) given at the end of the book is scarcely explained adequately. Kinetic theory is not dealt with separately but is developed as required alongside the rest of the subject. This perhaps is as it should be, but the author just misses going far enough to throw light on certain phenomena: for example, the laws of expansion of steam under particular conditions remain an unresolved mystery to a reader of this book, the appropriate formulæ being merely referred to as empirical —an almost inevitable corollary to ignoring Callendar's work. Again, in turbine work, scant recognition is accorded to the contribution of workers in Great Britain, and, where practice here is at variance with or even in advance of that given, no hint as to the facts is indicated.

A brave attempt is made to cover the subject of heat-transfer in its higher flights in two chapters, with inevitable gaps. For example, the author's

method of solving the unsteady-state conduction problem receives prominent attention; but no mention is made of other methods of tackling these problems. The Fourier analytical solution of the general unsteady-state equation is omitted. On the other hand, the application of the theory of similarity to heat-transfer problems is presented mathematically, but only in a manner which will conceal its importance from the reader not well equipped in that direction. The radiation of both non-luminous gases and luminous flames is not dealt with.

Notwithstanding these criticisms, there is a vast amount of careful, clear and painstaking explanation of various aspects of the subject. The more advanced sections, however, are open to the criticism that usually the German method of treating the various problems is given: however excellent, a comparison with methods more familiar in Great Britain would be valuable. In general, the book follows many others of Continental origin in appearing to imply that any reasonably competent person reading from the beginning to the end can become an expert in the subject, whereas in actual fact all too many find they have a ceiling beyond which they cannot rise. There is no indication to such as to which are the important points.

Summing up, it may be said that this is a valuable and useful contribution to the literature of the subject in the English language, if read in conjunction with other books or under suitable guidance.

A. L. Bird

GAS TURBINES

The Theory and Design of Gas Turbines and Jet Engines

By Prof. E. T. Vincent. Pp. ix + 606. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 64*s*.

In a world already sated with technological literature, if an author feels it impossible to resist the urge to go into print, it is surely his first duty to be as concise as possible. A student to-day has not the time to separate out the essentials and the irrelevancies in a text-book. The gas turbine is a particularly suitable subject for the practice of precise writing, for, in the elementary forms in which it should be presented to students, it is one of the simplest heat engines that can be conceived. It should be possible to convey the essential facts about it in some two hundred pages of normal text-book size.

The author of this book, however, has decided to leave nothing to chance and plugs away at his subject for three times as long. By the time he is through, the exhausted reader, in addition to having a miscellaneous collection of basic formulæ in his head, has had to absorb a mass of irrelevant details of obsolete engines. This practice of mixing up the fundamentals of a subject with examples of current or out-of-date applications of the fundamentals and with details of practical points connected with the operation of the main and ancillary machinery is a common fault in modern text-books. In fairness to the author, it must be added that this book is certainly no worse than many others on the same subject.

The book is at its best when dealing with the straightforward dynamics of flow in compressors and turbines, although much of the material appears to have been taken almost bodily from the author's sources. The chapter on combustion consists mainly of a description of existing chambers and techniques, with little of the underlying theory. Chapters are also included dealing with jet propulsion, in which the arithmetic of the propulsive jet is very fully presented; with materials, including miscellaneous data on a number of materials, some of which are of interest to engineers at the present time; and with regenerators, in which some useful formulæ for calculating heat flow are given without really getting down to the kernel of the heat exchanger problem. The book would gain very greatly if the author had given physical explanations of the phenomena occurring instead of usually remaining content with presenting the bare mathematical equations.

The standard of gas-turbine text-books is so very low that, in spite of the hard words written above, this book is probably one of the best so far produced on this subject. But we still have to wait for a work on the gas turbine equivalent to D. R. Pye's classic volumes on the internal combustion engine.

H. Constant

SCIENCE AND LITERARY CRITICISM

Science and Literary Criticism

By Prof. Herbert Dingle. Pp. viii+184. (London and Edinburgh: Thomas Nelson and Sons, Ltd., 1949.) 7*s*. 6*d*. net.

The author has performed a valuable service in writing this short but stimulating book. It divides naturally into two parts: the first debates the question as to whether a science of criticism is possible—and the short answer is "scarcely"; whereas in the second, some illuminating comments are made on the work of three poets to illustrate the way in which a scientific *Methodik* might help.

Although Prof. Dingle does not remind his readers that a 'poet' originally meant a 'maker', it may be hoped that they will recollect this derivation and keep it before them, for it adds weight to these penetrating analyses of Wordsworth, Swinburne and Browning. It is no use, we are told, to revel in the beauty of a poem if we would try to be critics: we only discover ourselves that way, and not the poet. Wordsworth sought happiness first—a blissful enjoyment impervious to detail. Such an outlook is not inconsistent with his idea of truth, which is more akin to dreaming than to intellectual veracity.

By contrast, the problem of Swinburne is to discover his 'vectors' which point outwards from his 'internal centre', about which, aforetimes, Meredith and Mrs. Meynell were rather unkind. It is seen, however, to be an exceedingly complex phenomenon, connected in some way with a passion for the infinite. In this context, the contrast with Shelley's psychological constitution is well brought out.

Finally, the intellectuality, or its absence, of Browning is reviewed, and it becomes manifest that the reply to the query whether he was scientific is "definitely not".

Much of all this is applicable to the arts in general: for example, Browning's incapacity to generalize puts him, in this respect, in company with Leonardo da Vinci who, in spite of his inventive powers, lacked scientific, and still more mathematical, ability in the fundamental sense. Such matters will interest a wide circle, and this scholarly contribution deserves the warmest of welcomes.

F. I. G. Rawlins

Lord Lister, his Life and Doctrine

By Douglas Guthrie. Pp. viii+128+21 plates. (Edinburgh: E. and S. Livingstone, Ltd., 1949.) 15*s*. net.

THE serious student of Lister's life and work has abundant sources of information available in such books as Sir Rickman Godlee's standard "Life of Lister" (1917, revised edition 1924), Sir William Cheyne's "Lister and his Achievements" (1925), the "Lister Centenary Exhibition Handbook" of the Wellcome Historical Medical Museum (1927), H. C. Cameron's "Joseph Lister: the Friend of Man" (1948), and Lister's "Collected Papers" (1909). Some of these, and other classical biographies, are out of print and not easy to obtain. The medical student, the medical practitioner and the layman will be grateful to Dr. Douglas Guthrie, lecturer on the history of medicine in the University of Edinburgh, for providing them with a small, readable, attractively produced, modestly priced and up-to-date addition to the literature.

To the medical historian the most valuable feature of this book will be the inclusion of autograph letters in the possession of the University of Edinburgh and of the Royal College of Surgeons of England, published here for the first time, particularly one letter in which Lister suggested that *Penicillium* might influence the growth and activity of bacteria. The story of this is told in the *Annals of the Royal College of Surgeons of England* (**6**, 140; February 1950), with comments by Sir Alexander Fleming.

The author's excursions into contemporary history, medical and general, and his pleasing pen-portraits of such men as James Syme will be welcomed by the reader, who will also appreciate the conveniently short sections and the copious subheadings. "1914" on p. v should read "1917", and "1886" on p. 62 "1868".

W. R. BETT

An Annotated Checklist of the Birds of Malaya

An Annotated List of the Birds occurring, or known to have occurred, in the Territories of the Federation of Malaya and the Colony of Singapore. By C. A. Gibson-Hill. (Bulletin of the Raffles Museum, Singapore, No. 20.) Pp. 299. (Singapore: Raffles Museum, 1949.) 5 dollars; 12*s*.

THIS present volume is the fourth hand-list of Malayan birds published in the course of the past forty years. The two first were published by H. C. Robinson in 1907 and 1910, and in 1925 F. N. Chasen brought out his "Handlist of the Malaysian Birds", the last including Borneo and Sumatra, etc. This new volume differs considerably from its predecessors and should be very useful to the increasing numbers of bird students in the Peninsula. The area covered does not extend beyond the northern boundary of the Federated States, whereas in the former volumes part of Peninsular Siam as far as the Isthmus of Kra was included. This change the author considered necessary because there was not sufficient information available on the different species in the area between these two boundaries.

The distribution is given in some detail, and in the short paragraph under each species the author has added brief notes on the type of country inhabited, status within the area, whether the nest is known, and the reason for adding or omitting certain species or races. Mr. C. A. Gibson-Hill is to be congratulated on the way he has prepared the list, and, considering that he only joined the Singapore Museum in 1946, this is a remarkable piece of work. In his treatment of some species or races he is not always very happy, but it must be remembered that he has had to depend to a great extent on the views of others.

The spelling of the English names does not follow the usual custom, and may be an attempt at Basic English; but, possibly because I am old-fashioned, I prefer the spelling used by Chasen. It is to be hoped that the author, in spite of the present warfare in the country, is collecting material for a handbook of the birds of the Malay Peninsula. Robinson's volumes are too large and unwieldy, and unfortunately he was no field naturalist so that details of habits and breeding, etc., are lacking in his books.

N. B. KINNEAR

Metallurgical Abstracts (General and Non-Ferrous)

Editor: Lieut.-Colonel S. C. Guillan; Assistant Editor, Major W. G. Askew. Vol. 15, 1948. Pp. viii+750. (London: Institute of Metals, 1948.) £3.

THE outstanding characteristic of these abstracts of the Institute of Metals is their unvarying excellence. The ground covered may be realized from the facts that there are 624 pages—with probably something of the order of six abstracts per page—and that the subject index extends to more than seventy pages. The papers dealt with are adequately and expertly summarized, and there is no difficulty in getting a detailed idea of the ground covered and the sort of results obtained.

Perhaps one of the most surprising features of the volume is the range of publication examined; not only are the outstanding scientific journals included in the reviews, but also a very large number of others, the very names of which will be unknown to many. The care with which overseas literature has been examined appears to be as adequate as that of British publications. In addition to the formal abstracts, there are reviews of books dealing directly or indirectly with the interests of the Institute, and a bibliography of books, specifications, reviews, etc., which covers a wide field. Within the limits of the Institute's sphere, it is difficult to believe that a more adequate abstracting service could be provided.

F. C. T.

Foundations of Modern Physics

By Prof. Thomas B. Brown. Second edition. Pp. xvi+391. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949.) 30*s*. net.

IT is natural that in a book which covers a wide field, including electronics, nuclear physics and the theory of elementary particles, major revisions and additions were necessary in preparing a second edition of Brown's "Physics", the first edition of which appeared in 1940. An introduction and epilogue have been added in which the objectives and philosophy of the book are explained. The emphasis throughout is upon the experimental aspect and upon the evidence which these experiments give in support of the theories whereby the results are interpreted and explained.

The book is intended for the non-specialist and should stimulate his interest for further reading and study. To help him, every chapter concludes with a list of carefully selected references divided into two groups consisting of less and more advanced texts. The book is excellently produced with numerous clear diagrams and interesting photographs. It should be in every university library and in many school sixth-form libraries.

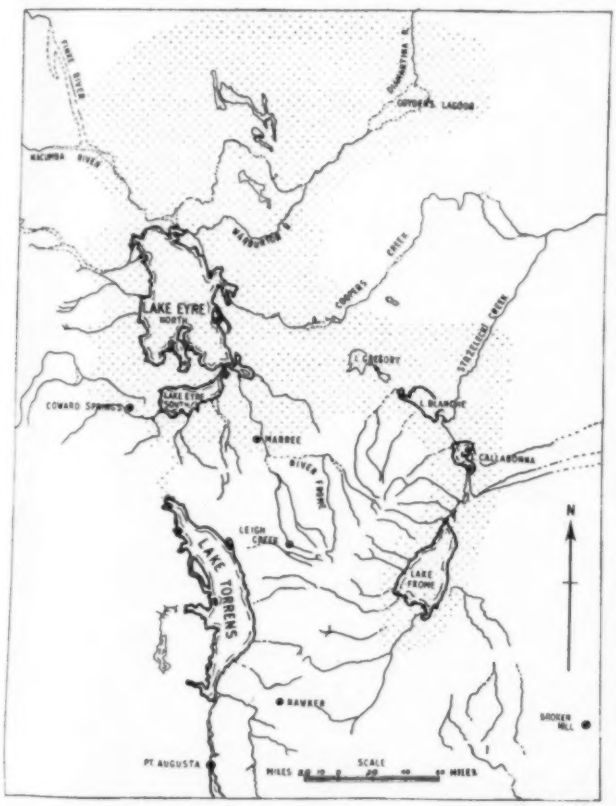
S. WEINTROUB

OCCURRENCE OF WATER IN LAKE EYRE, SOUTH AUSTRALIA

By Sir DOUGLAS MAWSON, O.B.E., F.R.S.
University of Adelaide

INDISPUTABLE evidence of the existence during Pleistocene times of extensive lakes in the north-eastern portion of South Australia has long been recognized by Australian geologists. Lake Eyre and Lake Frome and other minor salinas of that region are but the dried-up shrunken remnants of that formerly extensive body of water. It was fed by a number of once great rivers rising as much as a thousand miles away in the western highlands of Queensland. At its greatest extension, the area of this palæogeographic feature was possibly of the order of very many thousands of square miles. It derived its name, Lake Dieri, from that of a tribe of aborigines who formerly inhabited the country to the east of Lake Eyre. In some localities, the limits of the former lake are clearly defined by former shore-level terraces.

Since White occupation, these lakes have been dry, or at the most have received only rare and ephemeral contributions of water, the last of any note being about fifty-six years ago. The dry bed of Lake Eyre is about sixty or more feet below sea-level. In the heyday of Lake Dieri, there must have been a depth of several hundreds of feet of water, for it overflowed into Lake Torrens and thence to the sea at Port Augusta on Spencer Gulf.



In the pluvial period of the Australian Pleistocene, this great inland sheet of water was mainly fed by long rivers flowing south-west from the western slopes of the east-coast ranges of tropical Queensland. Of these the main relics now existing are the intermittently flowing Diamantina and Cooper Creeks. Other though less important contributions were forthcoming from the north-west by way of the Finke and the Macumba Rivers. In the Pleistocene, crocodiles of north Queensland origin inhabited Lake Dieri, and gigantic herbivorous marsupials occupied the surrounding country, which had a thick plant cover. Now all that remains of that once virile population is their fossilized remains occasionally met with in the lacustrine sediments.

The floors of the saline remnants of the old lake are occupied by gypseus and saliferous muds. Some years ago, the late Dr. C. T. Madigan found an upper crust of 17 in. of salt on the saliferous muds of Lake Eyre.

During the past two years the incidence, distribution and amount of rainfall in Australia have been exceptional. Most notable has been the unusually heavy and sustained rainfall in the eastern States, and in none more marked than in Queensland. There has been a remarkable flooding of the western plains of Queensland. The normally dry channels of the once great rivers, for example, the Diamantina and Cooper, have sprung to life again and are pouring vast quantities of water into the bed of Lake Eyre. Transport has been dislocated over wide areas and the occupants of sheep and cattle stations marooned.

Several South Australian pastoralists have recently returned from an investigation of the present state of Lake Eyre. They report flood waters extending far beyond the main channels of the rivers entering the lake. In the case of the Cooper, the swirling current in the main channel was found to be moving south at the rate of about four miles an hour. The Lake, when last reported, was a vast sheet of water, fresh and muddy where the rivers entered, but elsewhere salt. By means of a boat transported to the Lake, the muddy shore waters with a depth of a couple of feet were found to pass into clear saline waters with a depth of up to 12 ft. at a distance from the coast.

Viewed from the air, occasional small islands were observed in the body of the lake. The carcases of creatures such as rats, insects and the like, drowned by the floods, were found to have attracted vast numbers of water birds, particularly pelicans and ducks of every description, but also flocks of seagulls and cormorants that had travelled far inland to partake of the orgy.

Everywhere the surrounding country, normally a veritable sandy desert, is now

clothed in a wonderful growth of Mitchell grass, cane grass, wild geranium, acacias and abundance of wild flowers, of which everlastings are most obvious.

Surely no better example has been recorded of the sudden transformation of a desert to comparative fertility consequent on a temporary, perhaps cyclical, variation in the local atmospheric circulation.

SURVIVAL OF SPERMATOZOA AT LOW TEMPERATURES

By Dr. A. U. SMITH and Dr. C. POLGE
National Institute for Medical Research, London, N.W.7

IT is well known that some organisms have a remarkable capacity for surviving exposure to very low temperatures, and certain facts stand out clearly from the extensive literature reviewed by Luyet and Gehenio[1]. Organisms which can withstand desiccation are able to revive and resume growth and reproduction after cooling, in the dried state, to temperatures close to absolute zero. Some other cells will survive without desiccation provided that they are cooled and afterwards warmed so rapidly that the protoplasm is vitrified and thawed without formation of ice crystals. Luyet believes that the preservation of life at low temperatures depends on preventing the formation of intracellular ice crystals, either by dehydrating the cells before freezing, or by ultra-rapid cooling and rewarming. A variety of living organisms including certain bacteria, yeasts and fungi can, however, be revived from very low temperatures without preliminary desiccation, whether cooled slowly or quickly. Other cells in the wet condition, for example some trypanosomes, trichomonads, microfilaria and hookworm larvæ, survive slow cooling to −70° C. better than quick cooling[2]. For the survival of leukæmia cells[3], and the active forms of nematodes, rotifers and tardigrades[4], slow cooling is essential.

Spermatozoa show great differences from species to species in their resistance to low temperatures, and not only the rate of cooling but also the medium in which they are suspended influence the proportion reviving. Thus, fowl semen undiluted, or in Ringer's solution, shows no motile spermatozoa after freezing either quickly or slowly to −79° C. or −196° C., whereas when the semen is diluted to contain 20 per cent glycerol the spermatozoa resume full motility after cooling to, and storage at, −79° C.[5]. Slow cooling is only necessary when the glycerol-containing semen is frozen in thin-walled capillary tubes or films[6]. In protecting the spermatozoa against low temperatures glycerol appears to be outstanding. Among the large number of polyhydric alcohols and their derivatives so far examined by us, only ethylene and propylene glycol in final concentrations of 15 or 20 per cent will permit normal motility of fowl spermatozoa and give revivals approaching those with glycerol. Other substances, for example, the α- and β-methyl ethers of glycerol, diethylene and trimethylene glycol, and the monomethyl and monoethyl ethers of ethylene glycol, are more toxic and give less protection against low temperatures.

The spermatozoa of most mammals have proved more sensitive than those of fowl to rapid cooling. Human spermatozoa are exceptional, for even in undiluted semen a proportion will withstand exposure to the temperatures of solid carbon dioxide, liquid nitrogen and liquid helium[7,8], although the revival can be improved both by increasing the volume frozen[8], which presumably decreases the rate of cooling, and by dilution to contain 5 per cent glycerol or 5 per cent propylene or ethylene glycol[8]. By contrast, the revival of bull and goat spermatozoa depends both on dilution of the semen to contain a final concentration of 15 per cent glycerol in a citrate buffer solution, and on slow cooling, taking at least 40 min. to pass from 0° C. to −79° C.[10].

According to our present experience, horse spermatozoa are more difficult to revive from low temperatures; they must be separated from the seminal plasma by centrifuging, re-suspended in a phosphate buffer solution containing 5 per cent glucose and 30 per cent glycerol and cooled slowly to −79° C. About 25 per cent of the spermatozoa may then resume full motility on thawing, whereas few revive after rapid freezing. When guinea-pig spermatozoa are frozen rapidly in presence or absence of glycerol none revives. If, on the other hand, they are suspended in a glucose-saline solution buffered with phosphates and containing 15 per cent glycerol, and cooled slowly to −79° C., about 75 per cent resume active movement after thawing, although their acrosomes are severely distorted or absent. So far, definite morphological changes have not been seen in spermatozoa of any other species after cooling in the presence of glycerol. Rabbit spermatozoa differ from those of other species so far examined by their intolerance of glycerol in concentrations higher than 2·5 per cent in Ringer's solution or buffered saline and glucose-saline solutions at 20° C. If, however, rabbit semen is diluted with equal parts of either 10 per cent glycerol in distilled water, 20 per cent glycerol in 0·25 per cent gum arabic, or 30 per cent glycerol in 0·1 per cent methyl cellulose, the spermatozoa are highly active. Even in these diluents only 30 per cent are fully motile after slow cooling to −79° C. and subsequent warming to 40° C., and none survives rapid freezing. These results stress the importance of the rate at which the spermatozoa are cooled, and the composition of the medium in which they are suspended, for their revival from low temperatures. They do not support the view that rapid cooling to prevent crystal formation is the most important factor in their survival. In order to study changes in the medium and changes within the cell during cooling, a method has been devised for freezing material to very low temperatures under direct microscopical observation[6]. The results indicate that glycerol modifies the process of ice crystal formation and dissolution in the medium, so that damage due to pressure and other mechanical effects is reduced. Crystal formation within the spermatozoa is not seen, although, as shown by ultra-violet photomicrography, in the absence of glycerol their heads and midpieces are severely damaged by freezing.

It must be emphasized that the above results relate only to the motility of the spermatozoa after freezing. Satisfactory fertilizing power has so far not been demonstrated with any species. Glycerol-treated fowl semen has been inseminated into a large number of pullets. Out of more than two thousand eggs laid by birds inseminated with semen containing 5–20 per cent glycerol none has been fertile, whether the semen was frozen or not. This result indicates that the addition of glycerol alone caused loss of fertilizing power, whatever further effect freezing may have had. In later experiments it was found

that 1 per cent is the maximum concentration of glycerol which unfrozen fowl semen will tolerate without losing fertilizing capacity, and in this concentration only an occasional spermatozoon survives freezing to −79° C. Nevertheless, out of six hundred eggs laid by hens which had been inseminated with semen frozen in the presence of 1 or 2 per cent glycerol three chicks were hatched, and one embryo died between the fifth and eighteenth day of incubation. It seems likely, therefore, that the very few spermatozoa which survive freezing under these conditions retain their fertilizing power. The possibility is now under investigation that, as in the experiments of Shaffner[11], a considerable proportion of eggs were fertilized by frozen and thawed spermatozoa, but that the embryos died in the early stages of development. Attempts have been made to reduce the concentration of glycerol required to protect fowl spermatozoa against low temperatures, or to prevent its adverse effects on fertilizing power, by incorporating other substances in the diluting fluids.

Among the substances tried are lecithin, egg yolk, egg white, milk, glucose, fructose, mannose and other sugars, and different buffer substances and colloids. So far, no diluent more effective and less harmful than glycerol in Ringer's solution has been found. With propylene and ethylene glycol a concentration of 6 per cent in fowl semen permits normal fertility of unfrozen material; after freezing in this concentration, however, few spermatozoa are active, and the semen is infertile. A concentration of 10–20 per cent of these substances severely reduces the fertility of unfrozen semen, so that after insemination only three fertile eggs were obtained out of four hundred laid by pullets. Two live chicks and one dead embryo were obtained, however, from about the same number of eggs laid by hens inseminated with frozen semen.

The mechanism by which these substances reduce the fertility of fowl semen is being studied. With the semen of mammals reduced fertilizing power is often associated with low oxygen consumption[12]. Preliminary metabolism studies indicate that glycerol reduces the oxygen consumption of fowl spermatozoa at 25° C. to a level which is not further reduced by subsequent freezing and thawing. This adverse effect of glycerol on the fertilizing power of spermatozoa does not appear to be general. Rabbit semen diluted with 20 per cent glycerol in 0·25 per cent gum arabic, or 30 per cent glycerol in methyl cellulose, has been used for insemination and shows unimpaired fertilizing capacity; but so far only one fertile egg has been found among fifty-three recovered from the does inseminated with frozen semen. The impaired fertility may be due, in the rabbit, to reduced motility of the semen when thawed. As regards other species, there are special difficulties with other laboratory animals for work involving artificial insemination. Experiments have been started with cattle; but progress is bound to be slow.

A number of interesting problems are raised by this work. First, the harmful effects of changes in the medium during freezing and thawing must be considered, and distinguished from those of changes in the cell itself. Alterations in the medium might damage spermatozoa by mechanical effects such as pressure and tension during crystallization and thawing, or by physicochemical means such as altered tonicity during and after removal of water as ice. Glycerol in the medium appeared to reduce mechanical damage; but whether it altered the physical and chemical state of the electrolytes and non-electrolytes after they had been concentrated by freezing, so as to reduce their harmful effects on the cells, is not clear. Changes within the spermatozoa must be even more complicated, and probably vary from species to species. Our microscopic studies of freezing amœbæ[6] support Luyet's view that a cell has little chance of surviving if free water crystallizes within it to form ice. Spermatozoa may, however, have a low content of free water, and it seems that the risk of intracellular ice formation due to slow cooling is less important than the deleterious effects of rapid temperature changes which are known as temperature shock in the range above zero[12] and seem also to operate in some form in a range far below. Secondly, the possibility that chemical and physical agents including temperature change have different effects on different parts or functions of the same cell must be borne in mind. The action of glycerol on spermatozoa is obscure, and whether it influences the permeability of the cell membrane or whether it penetrates into the cell is not known. It is clear that in some species glycerol exerts a different effect on the midpiece and tail which are responsible for motility, and on the head which is directly concerned with fertilizing the ovum. Thus, media containing glycerol in high concentrations support good motility of fowl spermatozoa but reduce their oxygen consumption and fertilizing capacity, whereas with rabbit spermatozoa glycerol reduces the motility but not the fertilizing power of the unfrozen semen. The exact nature of these changes remains to be elucidated.

We are indebted to our colleague Dr. D. Herbert for carrying out the metabolism experiments on fowl spermatozoa.

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PRODUCTION AND UTILIZATION OF CHEMICAL ENERGY

A DISCUSSION on "Chemical Energy" arranged by Section B (Chemistry) of the British Association was held at Birmingham on September 5. It was opened by two papers by Prof. F. H. Garner, of the University of Birmingham, one of which served as an introduction to the general theme whereas the other dealt specifically with combustion reactions.

Prof. Garner, in his introductory talk, pointed out that the chemical energy liberated in a reaction may appear in several forms, notably as heat, light or electrical energy. The main sources of chemical energy are those which have been derived originally from the radiant energy of the sun and are stored in natural fossil fuels such as coal, petroleum, shale or peat. These are capital resources and, moreover, wasting assets the energy of which is made available by combustion processes, the liberated heat being used

as such or converted into mechanical or electrical energy. The transformation of heat into mechanical energy is a process of strictly limited efficiency because of the operation of the Second Law of Thermodynamics, and all heat engines have relatively low efficiencies, usually less than 40 per cent.

Prof. Garner stressed, however, the importance of energy being produced in a convenient form, for this factor is often of greater importance than that of thermal efficiency, and the factor of cost inevitably enters into considerations of energy utilization.

Most of the efficiencies attained in the utilization of chemical energy are extremely low; for the production of industrial power and heat from coal, the average overall efficiency has been calculated to be 17 per cent. Thus, although steam may be generated at thermal efficiencies of 85 per cent, the conversion to mechanical energy at an efficiency of 35 per cent gives a combined efficiency of only 30 per cent. The conversion of mechanical energy to electrical energy is, however, an efficient process, and consequently the overall efficiency of electricity generation can be as high as 29 per cent. Where heat energy is used at high temperatures, for example, in metallurgical and glass furnaces, efficiencies attained are low since the waste gases are discharged at high temperatures. By employing these hot waste gases for steam generation or for pre-heating the air to be used for combustion of the fuel, or in other ways, much can be done to raise efficiencies.

Liquid fuels are preferred for transport by sea, land and air, due largely to convenience in handling, and ease of flow and control in the power unit itself.

In his second paper, Prof. Garner considered the efficiency in use of the chemical energy from combustion, in heating processes and in its conversion to mechanical and electrical energy.

The use of fuels in their natural state leads to high thermal efficiencies only in a few applications, one of the chief of which is steam raising, where thermal efficiencies of 90 per cent are obtainable in efficient power stations; although only where the steam can be used efficiently can a high overall figure be attained.

In the field of transportation, there are three forms of internal combustion engine: the spark-ignition (petrol) engine, the compression-ignition (diesel) engine, and the gas turbine. The efficiency of spark- and compression-ignition engines depends upon the compression ratio employed. Ricardo showed that unless suitable fuels are supplied for a given value of the compression ratio, 'knocking' occurs with its attendant tendency to pre-ignition, loss in efficiency and possible damage to the engine. In order to enable high compression ratios to be used, aromatics were introduced as the first anti-knock agents; but later, processes for cracking petroleum were developed. Cracked gases are now largely converted by processes of polymerization, alkylation and isomerization to synthetic hydrocarbons which have made possible the modern high-octane aviation fuels still further improved by the addition of lead tetraethyl.

The diesel engine is thermally more efficient than the petrol engine and is finding increasing use in the larger-size units, as in rail and sea transport.

The thermal efficiency of the motor-car engine is only about 6 per cent in the United States; owing to the higher cost of fuel in Great Britain, smaller and more efficient engines have been developed. The figure is low, since most of the time the engine is producing power equivalent to less than one-quarter load. The aircraft engine which operates mainly at full load reaches an efficiency of 12 per cent.

Prof. Garner drew an interesting comparison between the coal-fired steam and the oil-fired locomotive and the diesel-electric locomotive, with thermal efficiencies of 4, 6 and 26 per cent respectively, and pointed out that in the United States this is leading to a rapid replacement of the steam locomotive by the diesel-electric engine for railway purposes.

In conclusion, Prof. Garner dealt with the gas turbine, which for aviation purposes employs kerosene as fuel. The gas turbine does not demand a fuel of high octane or cetane number; but fuels other than clean distillate fuels may lead to deposits on, or erosion of, the turbine blades. In particular, petroleum residual oils of low ash content have led to serious deposits, apparently due to the minute contents of vanadium of the order of 0·04 per cent or less. The future of the larger-sized gas turbines, for which efficiencies of more than 30 per cent are expected, appears to depend on the extent to which the natural fuels, coal and petroleum, can be used.

Dr. James Taylor (Nobel Division, I.C.I., Ltd.) pointed out that there is another important class of chemical reaction which man has harnessed to replace human effort. These diverse exothermic reactions are not economic methods of providing energy except for providing high power for very short intervals of time, or for use under conditions where atmospheric oxygen is not available. Many of these reactions are very violent, as, for example, in high explosives, whereas in other cases the rate depends upon the pressure of operation, and the materials, for example, cordite, can be used as propellants.

The important property of explosives is that they are self-propagating when initiated or ignited from a local point. In the case of high explosives, 'point' initiation is normally provided by a local intense shock or blow as from a detonator, which comprises a small metal tube filled with an explosive such as fulminate of mercury. Initiation in the case of propellants, such as cordite or incendiary mixtures, is usually thermal in character, generally by means of a flame.

Dr. Taylor traced the development of explosives from gunpowder to the detonating explosives in which reaction is initiated and sustained by a mechanical shock wave passing at high velocity through the explosive. Such explosives are of vital importance in civil and mining engineering. For mining purposes, gunpowder cannot be used safely where methane/air mixtures are liable to occur. The position has been completely altered by the advent of detonating explosives; and by the incorporation of cooling materials like common salt into explosives based on nitroglycerine (or T.N.T.) and ammonium nitrate, the so-called 'permitted' explosives have been developed. In rockets, black powder has been displaced by cordite, and these are now used for the assisted take-off of aircraft; recently increasing attention has been given to the use of propellants as controlled energy sources for performing mechanical operations. The power cartridge field includes cartridges for starting aero engines, for the ejection of pilots from high-speed aircraft in an emergency and for a variety of other purposes.

Gentler types of mixture were also discussed, and reference was made to a cartridge developed for insertion into tinned soup for providing hot refreshment for troops during the War. Another mixture of antimony and potassium permanganate has been

used in making delay fuses for detonators, and these can be used for controlled blasting.

The decomposition of ammonium nitrate is extremely complex and does not occur readily in normal circumstances; however, certain substances such as potassium chromate or ammonium dichromate, added in quantities of the order of a few per cent, cause the self-sustained decomposition of this substance. Such compositions can be pressed into compact cylinders and will provide gas steadily for long periods. They can be used for driving motors or as fuels for rockets and jet-propelled devices. Guanidine nitrate compositions have been used for operating jet propulsion units for model aeroplanes and motor-cars.

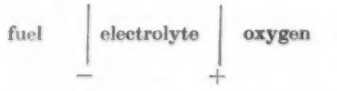
Liquid mono-propellants such as concentrated (80–85 per cent) hydrogen peroxide, methyl and ethyl nitrates, nitromethane and other substances were discussed, and the use of the first in the launching device for the German *V*1 weapon was mentioned. Bi-propellants such as liquid oxygen and alcohols, or concentrated nitric acid and aniline, have been used in rockets of the *V*2 type.

Dr. Taylor illustrated his lecture by means of a series of carefully executed and spectacular demonstrations which proved to be exceedingly popular with his audience.

The third speaker, Dr. H. J. T. Ellingham (Royal Institute of Chemistry), discussed the direct conversion of chemical energy to electrical energy. He pointed out that a voltaic cell may be regarded as a device for converting the 'free energy' of a reaction into electrical energy. In principle, almost any type of spontaneously occurring chemical reaction is capable of being harnessed in a voltaic cell. In practice, however, few types of reaction have been effectively used in this way, and the operation of practically all established forms of primary cell is based on the oxidation of a metal (generally zinc) to one or other of its compounds. If an efficient cell could be developed to harness the oxidation of carbon, it might provide an alternative means for the large-scale generation of electrical energy from coal. The possibility is attractive, because no upper limit of efficiency is set by the Second Law of Thermodynamics as in the heat-engine stage of the existing process. Even if it proved impracticable to make use of the direct oxidation of coal or coke, there might still be scope for an indirect fuel cell operating on the oxidation of secondary fuels such as hydrogen or carbon monoxide.

Possible reactions were discussed in some detail and it was suggested that metals such as tin or lead, which can be obtained by carbon reduction at relatively low temperatures, would be preferable for use in cells to higher-melting metals or those with much greater affinity for oxygen.

The general form of a fuel cell is



The oxygen would preferably be supplied as air to avoid the cost of separation. During the discharge of such a cell, oxygen ionizes at the positive electrode giving oxygen or oxygenated ions (hydroxyl ions in aqueous solution), while at the negative electrode *either* the fuel substance ionizes (hydrogen or the metals yielding positive ions) *or* the oxygen or oxygenated ions in the electrolyte are discharged, forming nascent oxygen which then reacts at the anode surface with the fuel substance.

Neither carbon nor carbon monoxide can furnish corresponding ions, and their use in a fuel cell depends on their being oxidized anodically by nascent oxygen —a reaction which only proceeds at a reasonable rate at an elevated temperature. Oxygen does not give a reversible electrode system as does hydrogen adsorbed on the surface of platinum; however, oxygen diffusion electrodes have been developed, and temperatures of more than 200° C. have been used for hydrogen – oxygen cells in aqueous solution working at pressures up to 55 atmospheres. The fact that raising the temperature increases rates of reaction and diffusion makes the prospects of fuel cells with molten-salt electrolytes seem attractive.

Dr. Ellingham reviewed experimental work upon molten-salt electrolyte fuel cells and suggested that they might be designed to convert more than 30 per cent of the chemical energy to electrical energy.

In conclusion, it was suggested that more attention might be given to the possibility of linking cell reactions consuming secondary fuels with the process of production of the fuel from carbon, in which manner improved heat economy might be attained.

Prof. F. G. Gregory (Imperial College of Science and Technology, London), who concluded the discussion, considered the building up of chemical energy by vegetation, and discussed estimates which have been made of the material turnover in the carbon cycle in terms of the amount of carbon fixed per annum from the atmosphere and oceans.

The amount of solar radiation reaching the earth's surface can be estimated, and an approximate value obtained for the amount of suitable radiation available for photosynthesis. From these results it is possible to deduce a rough value for the efficiency of utilization of solar energy by vegetation, and this is found to be of the order of 1 per cent. The factors controlling photosynthesis were discussed and figures given to show that plants very dissimilar in nature assimilate at the same rate under the same conditions.

A thirty-fold increase in concentration of carbon dioxide only results in a four-fold assimilation, and although an increase in temperature results in an increase in assimilation-rate up to 25° C., this appears to be the optimum temperature. Experiments have shown that total assimilation varies little with the latitude at which the vegetation grows.

Experiments were described with a number of plants such as barley, cotton, mangold and sugar beet, in which the net assimilation-rate in terms of dry-matter increase per unit leaf area per unit time was determined. The results show that for these plants growing in very different environments and at different levels of nutrition, the net assimilation-rate varies only within narrow limits.

By burning the dry material in a bomb calorimeter, the energy content can be found, and by recording the varying intensity of radiation which has fallen on the plants over a period and knowing the mean leaf area, the efficiency of energy storage can be determined. This is of a low order, never exceeding 1·5 per cent for varying levels of manuring. It appears, therefore, that neither by varying the plant nor the fertility of the soil can the efficiency of energy accumulation be greatly changed, although the total quantity of dry matter can be increased if the total leaf surface is increased by more rapid development of the plants.

There appears to be little hope that the efficiency of the photosynthetic process can be increased by selection or breeding.

On the basis of this information, Prof. Gregory considered the most effective methods of utilizing plant growth for storing solar energy. The most convenient product would be sugar or starch in the form of stored products in tubers or roots, which would be readily convertible to alcohol by fermentation processes. Prof. Gregory mentioned schemes which have been suggested for using micro-organisms, such as the green alga *Chlorella*, for the building up of chemical energy, and pointed out that there are so many difficulties that the use of higher plants with storage organs would appear more economical.

R. Long

FUNCTIONS OF THE SKIN OF VERTEBRATES

Sections D (Zoology) and I (Physiology) of the British Association joined forces on the morning of September 1 to hear a group of papers on the functions of the skin.

Prof. P. B. Medawar (Birmingham) opened the session by discussing the anatomy of the mammalian epidermis, referring specially to the anatomical basis of pigmentary activity. He said that standard text-book diagrams of transverse sections of the skin are almost invariably at fault in their complete omission of the cells responsible for melanin formation—the cells variously called dendritic cells or epidermal melanoblasts or melanophores. Dendritic cells form a distinct lineage in the epidermis, and, as American work has shown, arise in development from the neural crest. The dendritic cell is the sole origin and seat of pigmentary function in the epidermis. In some manner the melanin formed within it is caused to enter into the cytoplasm of the Malpighian cells on which its branches end, a peculiar mode of secretion which Masson has called 'cytocrine'. Studies of whole mounts of pure epidermal sheets, treated with Methylene Blue or the Dopa reagent, reveal the shape, number and distribution of dendritic cells with conspicuous clarity. In particular, they reveal that dendritic cells, which are so distributed in the basal layer as to lie at arms' length from each other, often anastomose to form local syncytia.

Prof. Medawar recalled R. E. Billingham's demonstration that white and negro skins resemble each other in the number, form and distribution of their dendritic cells. The difference between them is merely functional: the dendritic cell of negro skin maintains the higher level of pigmentary activity. The same is true of the difference between red and black skin areas in patched guinea pigs.

In conclusion, Prof. Medawar asked for a revision of text-book diagrams of the anatomy of the epidermis, and said that British dermatologists might well revise, or at least reconsider, the histopathology of skin in the light of this newer knowledge of its anatomy.

Dr. J. D. Findlay and Mr. W. R. Beakley (Hannah Dairy Research Institute, Ayr) reported work which throws quite a new light on the problem of temperature regulation in cattle. Dr. Findlay put the question whether cows sweat—indeed, whether they have sweat glands at all. Deep in the dermis of cows' skin lie large, poorly vascularized, sac-like glands lined with myo-epithelial cells which pass a colloid secretion through ducts on to the skin surface[1]. These are commonly called sweat glands; but there is no evidence that they are instruments of temperature control.

The climatological room at the Hannah Institute was described by Dr. Findlay. The room was designed to study the mode of heat loss in cattle. It can be kept at any temperature between 20° and 60° C., and at almost any humidity, with or without air movement; and suitable instrumentation makes it possible to keep a continuous record of the respiration-rate, heart-rate and skin-temperature of the calves kept in it. It has been shown that, at a constant saturation deficit, the skin-temperature rises in direct proportion to the temperature of the environment: there is no flattening or drop at any level to suggest that sweating has begun. Peripheral vasodilatation in calf skin is probably already at maximum at 20°. Moreover, injections of pilocarpine or adrenaline, which provoke sweating in horses, have no such effect on calves.

Presumably, then, said Dr. Findlay, the cow loses heat from the skin primarily by radiation—unlike the horse, but probably like the dog and sheep. The cow is therefore not well adapted to tropical climates; but, as Bonsma has shown, the cow best adapted as a radiator of heat is one with a glossy coat of light colour bearing short hairs with pigmented tips. It is noteworthy that tropical cattle like the zebu have the same skin structure as those from more temperate climates. One reason for their superior heat tolerance is probably the very large dewlap which, since it has a particularly dense network of capillaries immediately below the skin surface, is probably an efficient extra radiator of heat.

Dr. W. S. Bullough (Sheffield) described his work on the replacement of the epidermis. Just as hairs might be replaced continuously, as in sheep, periodically, as in rats and mice, or seasonally, as in wild mammals, so the replacement of the epidermal layer is not a continuous and uniform process. There are recognizable patterns of replacement in space (for example, the anterior-posterior gradient of cell-division frequency in the skin of the mouse's back) and rhythms of replacement in time. All mice show a daily rhythm, and in female mice a rhythm in step with the œstrous cycle is superimposed on it.

Mitotic activity is high during natural or artificially induced sleep or at rest, and muscular activity is probably responsible for its fall by day. Injections of glucose or of phosphate before sleep raise the rate of cell division, and injections of phlorizin lower it. The blood-sugar level falls during rest, but significant quantities of glycogen are deposited in the skin as well as in the liver, and the rate of cell division at once rises. The facts, said Dr. Bullough, suggest that glycogen is the energy source that controls rate of cell division. It is noteworthy that although skin cultured *in vitro* in the absence of oxygen shows no new cell divisions, those started pass to completion. Oxygen, glycogen and phosphate all seem to act in advance of visible prophase—perhaps in an 'ante-phase' as little as fifteen minutes beforehand.

The general rise of mitotic activity during œstrus in female mice is no less conspicuous in the epidermis than elsewhere. Dr. Bullough suggested that œstrogen acts both directly, in influencing the frequency and completion-time of mitosis, and, indirectly, by mobilizing glycogen and causing its deposition in the epidermis, and by dilating the capillaries and perhaps increasing their permeability. The abundance of

œstrogen in plants hints at the possibility that it exerts a very widespread action as a controller of mitosis.

Dr. Bullough ended by saying that a study of mitotic frequency has obvious practical bearings. Lowering the food intake of mice by one-third depresses the rate of cell division, and is known to prolong their life, lower the frequency of tumour incidence and to discourage the multiplication of parasites.

Dr. J. S. Weiner (Oxford) dealt with the activity of sweat glands in man. He pointed out that an accurate census of sweat glands over the skin surface has still to be made, and that the degree of variation between individuals and races is unknown. We are largely ignorant even of the functional morphology of the individual gland. What, for example, is the blood supply of the duct of the gland, and what is the energy source of sweating? Work at Oxford has begun with an investigation of technique. In Japan, Kuno has shown it to be possible to cannulate the ducts of single glands, and it has now proved possible to dissect out individual glands for study in the microrespirometer. Sweat itself can be collected in an arm bag or by washing down the body surface with water. By this second technique, which has now been adapted for serial sampling, the production of sweat can only be computed indirectly from the change of body-weight. Arm sweat has proved to be more concentrated than body sweat, though the proportions of solutes in the two are the same. About 95 per cent of the osmotic activity of sweat can be accounted for: approximately 80 per cent is due to chloride, 10–11 per cent to lactate, and 2–3 per cent to urea.

Preliminary studies have shown that although sweat glands are subject to fatigue, the rate of sweating increases with time of exposure to high temperatures; its chloride concentration is related to the skin temperature. Acclimatization brings about increased sweating, and this is largely responsible for the increasing dilution of the sweat in the arm bag.

A clue to the source of energy for sweating is given by the fact that the lactate content rises in sweat from an arm rendered ischæmic by an arterial cuff. The chloride content drops in the earlier stages of ischæmia.

Prof. A. M. Boyd (Manchester) spoke of the treatment of excessive sweating by sympathectomy. The area of sweating can be mapped by painting the patient with a suitable indicator powder; but this is a messy method and its use makes it necessary to warm the patient up. It has been found possible to map the area of sweating by recording changes in the electrical resistance of the skin. The resistance of dry skin is only 10 per cent higher than that of damp skin; but the method now in use in Prof. Boyd's laboratory is sensitive enough to record it without warming the patient up.

Hyperhydrosis—excessive sweating—particularly of the extremities, can have serious consequences; fungal infection and the allergic dermatitis and ulceration associated with it can be so severe as to simulate gangrene. Sympathectomy can abolish hyperhydrosis over the area of denervation, and is, of course, used for the treatment of other disabilities as well—in the relief of arterial block, for example, to ensure the establishment of a good collateral circulation. To abolish hyperhydrosis of the legs and feet, a sympathectomy involving the second and third lumbar ganglia is not always satisfactory, for the area of denervation may sometimes be confined to as small an area as the inner aspect of the calves. The best result is to be achieved by sympathectomy involving the first lumbar ganglion as well, and Prof. Boyd dismissed as an illusion the idea that this operation affects the fertility of the male.

Among the matters that arose in discussion at the end of the morning's session were the unsatisfactory state of our clinical knowledge of leucoderma (local skin depigmentation). Prof. Medawar said that leucoderma may be due to a local destruction of pigment-forming cells or to a temporary suppression of their pigmentary activity; the latter is probably the explanation of the depigmentation caused by, for example, industrial anti-oxidants. In answer to a question on the distribution of mitoses in the epidermis, Dr. Bullough said that in his experience mitosis in normal skin is confined to the basal layer, that is, the epidermal cells at the dermo-epidermal interface. Mitosis may occur at a slightly more superficial level in hyperplastic skin.

[1] Findlay and Yang, *J. Agr. Sci.* (in the press).

OBITUARY

Mr. R. Winckworth

RONALD WINCKWORTH, who died at his home at South Norwood on September 6, in his sixty-sixth year, was one of the best known British malacologists. He was educated at Epsom College (1896–1902) and at Jesus College, Oxford, where he read mathematics (1906–10). After leaving the University, he held a number of scholastic appointments and was teacher of mathematics at Brighton Technical College (1912–14). On the outbreak of war, Winckworth enlisted as a seaman, and later became paymaster-lieutenant. He served in several of H.M. ships and saw service in northern European waters and at Gibraltar.

After the First World War, Winckworth's love of natural history led him to accept a post as assistant at the Marine Biological Laboratory, Plymouth, and it was here that he laid the foundation for his later work on Mollusca. He left Plymouth in 1921 and, after some miscellaneous teaching and lecturing, spent six months studying natural history in India and Ceylon.

In October 1925, he joined the administrative staff of the Royal Society and worked at first on publications and later as librarian. He became assistant secretary in 1932 and assistant editor from 1937 until his retirement, due to ill health, in 1944.

From 1925 Winckworth devoted much of his leisure hours to the study of British and Indian Ocean Mollusca and published many papers, mainly in the *Journal of Conchology* and in the *Proceedings of the Malacological Society*. He never missed opportunities of collecting in the field; but his official duties precluded much work on the living animal, and he became one of our foremost authorities on the systematics and bibliography of the Mollusca. His "British Marine Mollusca" (*J. Conch.*, **19**; 1932) will be long remembered as a successful attempt to stabilize the names of our molluscs. In collaboration with his brother (the late Col. H. C. Winckworth) he began a long-term project to study Indian Ocean Mollusca, particularly the nudibranchs. This was not completed, due to his brother's death and his own ill health.

Winckworth was enthusiastic and energetic in all that he undertook and was always ready to help students of Mollusca; all were hospitably received at his house at South Norwood. As editor of the *Proceedings of the Malacological Society* (1928–47), he gave many a beginner valuable aid and encouragement in writing a first paper, and the more experienced could always obtain sound advice on their problems. He was a simple and generous man, neat and methodical in his ways, and had a passion for orderliness in all things. His particular niche in British malacology will not easily be filled and his death will be felt as a personal loss by friends in many lands.

Winckworth belonged to many scientific societies and held office in several, including the Linnean Society of London (council 1943–47, vice-president 1945–47); the Malacological Society of London (council 1924–48, president 1939–42, elected honorary member 1949); the Conchological Society (president 1930–31). He was also a founder member of the Society for the Bibliography of Natural History and of the Systematics Association.

He first married Margaret Wallace, who died in 1939, and later Alison Mary Cruickshank, who nursed him with great devotion through a long illness.

W. J. Rees

NEWS and VIEWS

Radcliffe Observatory, Pretoria: Dr. H. Knox-Shaw

Dr. Harold Knox-Shaw has retired from the post of Radcliffe Observer and director of the Radcliffe Observatory, Pretoria. A pupil of S. A. Saunder at Wellington College and of A. R. Hinks at the Cambridge Observatory, he left Trinity College, Cambridge, in 1908 to become astronomical observer and afterwards director of the Khedivial Observatory, Helwan, Egypt. There his chief work lay in the photography of nebulæ and comets with the 30-in. Reynolds reflector. He secured the first photograph of Halley's comet at its return in 1910. In 1924 he succeeded Rambaut as Radcliffe Observer at Oxford, carrying on such work as measures of stellar parallaxes, and of Kapteyn's selected areas. The decision of the Radcliffe Trustees to sell the Oxford site to Lord Nuffield, to meet the growing needs of the Radcliffe Infirmary, was coupled with a plan to build a new 74-in. reflecting telescope in the southern hemisphere on a suitable site. While carrying on work on the reduction of stellar observations, including a long early series by Hornsby, Dr. Knox-Shaw's activities centred more and more from 1934 onwards on the erection of the new observatory buildings near Pretoria and of the telescope itself. A series of delays due to legal proceedings, difficulties in casting the mirror and the War prevented the arrival of the mirror in Pretoria until 1948, while even now the spectrograph for use at the Cassegrain focus, ordered and put in hand before the War began, has not been delivered. Much sympathy has been felt in astronomical circles with Dr. Knox-Shaw for the years of frustration that he passed through, but at least he has had the joy of seeing a first-class 74-in. mirror successfully at work in the telescope, and of knowing that a tremendously rich field of opportunity has opened up for the future. Dr. Knox-Shaw was president of the Royal Astronomical Society during 1931–33.

Dr. A. D. Thackeray

Dr. A. D. Thackeray, who succeeds Dr. Knox-Shaw as Radcliffe Observer, was educated at Eton and King's College, Cambridge. He was elected to the Sheepshanks Exhibition at Cambridge to work at the Solar Physics Observatory and later to a Commonwealth Fund Fellowship, with which he worked for two years at Mt. Wilson Observatory. He returned to Cambridge as assistant director of the Solar Physics Observatory, acting as director for a time in the early years of the War. In 1947 he became chief assistant at the Radcliffe Observatory. His work has been principally observational, covering a wide range of problems on stellar spectra, contours of absorption lines and on nebulæ. He has taken part in eclipse expeditions in Canada (1932) and Japan (1936). He has now a great opportunity of organising a wide programme of research in a very open field: happily, there is good prospect that his small staff will be supplemented by observers from other countries, who will make of the Radcliffe Observatory an important international centre of research.

Carty Medal and Award of the U.S. National Academy of Sciences: Dr. Irving Langmuir

The John J. Carty Gold Medal and Award of the U.S. National Academy of Sciences has been awarded to Dr. Irving Langmuir, who recently retired from the post of associate director of the General Electric Research Laboratory, Schenectady, New York. This Medal was established in 1930 in honour of the late John J. Carty, a member of the Academy, by his close associates, as a token of esteem on the occasion of his retirement from the vice-presidency of the American Telephone and Telegraph Co. It is awarded not more than once in two years and is given for noteworthy contributions to the advancement of fundamental or applied science in any field. Dr. Langmuir has received many high honours, among which may be mentioned the Nobel Prize in Chemistry (1932), his election as a foreign member of the Royal Society (1935), the Faraday Medal of the Chemical Society (1938), and the Faraday Medal of the Institution of Electrical Engineers (1944). His research work is remarkable for the extraordinarily wide range of his investigations. These include electric lighting, electron emission and gaseous discharge, surface chemistry and (during the Second World War) the production of smoke screens. Besides his interests in many branches of pure and applied science, Dr. Langmuir has made a number of valuable contributions to general scientific thought and the philosophy of science.

Geology at the Aligarh University

A Department of Geology has been created at Aligarh University and Dr. P. N. Ganju has been appointed reader and chairman of the new Department. Dr. Ganju has recently returned from King's College, University of Durham, where he specialized in coal petrology. The importance of trained geologists in India needs no emphasis; a great deal remains to be done in developing and exploring the mineral resources of this vast country. At the

moment, very few Indian universities have well-equipped geological laboratories and perhaps none is equipped for research in coal petrology. Dr. Ganju's appointment will help to initiate this work in this new field so necessary in the investigation of the coals and coal-fields of India.

College of Aeronautics, Bletchley: Prof. W. S. Hemp

A CHAIR in aircraft structures and aero-elasticity in the Department of Aircraft Design of the College of Aeronautics, Bletchley, has recently been established, and Mr. W. S. Hemp, formerly senior lecturer in aircraft structures and the deputy head of the Department, has been appointed as the first holder. Prof. Hemp, who is a graduate in mathematics of the University of Cambridge, joined the staff of the College in September 1946. During 1938–46 he was engaged on design and research work, mainly on structures, at the Bristol Aeroplane Co., Ltd., and during 1944–45, while in charge of the Project Stress Office, he carried out the preliminary structural and dynamical investigations on the *Brabazon* air-liner. He is the author of numerous research reports and a small monograph on stressed skin construction.

International Union of Biological Sciences

THE tenth triennial General Assembly of the International Union of Biological Sciences was held at Stockholm during July 7–11, presided over by Prof. M. J. Sirks (Netherlands), sixty-seven delegates from nineteen countries being present. The Union is one of a number of Unions representing different sciences under the ægis of the International Council of Scientific Unions. It comprises Sections of Biometry, Botany, Embryology, Entomology, Experimental Cytology, Genetics, Limnology, Microbiology and Zoology. It possesses limited funds derived from payments by adhering countries, and also acts in an advisory capacity to Unesco for the expenditure of money by the latter body on biological projects. Financial support has been given to nineteen type-culture collections of micro-organisms and *Drosophila* in various countries, to certain abstracting periodicals, to the preparation of directories of botanists, geneticists and zoologists, to the preparation of a list of the location of zoological type specimens, to international congresses and more particularly specialist symposia, to international commissions on zoological and botanical nomenclature, to the Zoological Station of Naples, to the International Depot of Cytological Preparations at Louvain, etc. A Commission of the Union is concerned with the biological control of pests, and there is a Joint Commission with certain other Unions on oceanography. At the close of the General Assembly the following officers were elected: *President*, Prof. H. Munro Fox (Great Britain); *Vice-President*, Prof. J. Runnström (Sweden); *Secretary-General*, Prof. P. Vayssière (France); *Secretary*, Prof. Stuart Mudd (United States); *Treasurer*, Prof. F. Chodat (Switzerland).

Rhodesian Agricultural College

THE opening of the Rhodesian Agricultural College at Gwebi by the prime minister of Southern Rhodesia, Sir Godfrey Huggins, on February 15, is a landmark in the country's farming history and will, it is hoped, prove a first step towards the creation of a Rhodesian university. The administration of the College is in the hands of an advisory committee, composed of prominent members of the farming and business world, and Dr. W. L. Fielding, formerly of the Cotton Research Station at Barberton, has been appointed the first principal. The farm covers 3,800 acres and contains a considerable arable area as well as extensive livestock paddocks. It originally formed part of the Government Experimental Farm and is already largely mechanized. Many buildings are in consequence available; but a hostel, lecture hall and staff houses have recently been built. New workshops are planned and the main college building will be also added later. A start has been made with twenty-four students and a staff of four. Officers of the Department of Agriculture and Lands will assist with lectures on special subjects, and instructors acting under a superintendent are to be in charge of the practical work. A general standard of education equivalent to that of the Cambridge School Certificate will be expected on entry, and the students will study a diploma course designed to cover two years. Emphasis will be laid on the practical aspects of farming, and sons of farmers will be specially encouraged to enter the College.

Scraper Tools in Prehistory

MANY years ago an author of a small book on prehistory described a scraper as "any odd bit of flint for which the prehistorian could not find a better name". Such a definition is no longer possible, and those who used to think it so should read Mr. A. D. Lacaille's exhaustive study, "The Scraper in Prehistory" (*Trans. Glasgow Archæological Soc.*, **11**; 1947). Obviously at all periods scraping tools were needed for many purposes—fashioning bones or wood, preparing skins, etc.—and, equally obviously, a variety of different forms would be required. The author passes these matters under review throughout prehistoric times. There is a large number of illustrations.

Organising for Output

IN order to help the man on the shop floor to understand some of the problems of production management, the British Institute of Management has prepared a booklet describing the technical side of a works manager's job ("Organising for Output"; 2*s.* 6*d.*). It does not pretend to teach men how to become managers but tries to show how the production side of a works is organised, the job that each member of the management staff is doing, and its effect on the productivity of the worker and the factory. Since so much has already been written about them, discussion of the work of joint production committees, works committees, and of the welfare department has been deliberately omitted. Among the topics discussed are managerial problems, the cost of the product, works organisation, production planning, storekeeping and stock control, work measurement and methods, engineering, shop and factory layout, work study and the worker's method, inspection, maintenance and incentives. A useful appendix describes the American labour unions' production engineering departments, and the booklet also contains a discriminately selected bibliography.

Indian Earthquake Observations

THE observatories of the India Meteorological Department, under the direction of Dr. S. K. Banerji, have seismological installations at Bombay, Calcutta, Kodaikanal, New Delhi and Poona, equipped with Milne–Shaw, Omori–Ewing and Wood–Anderson

instruments. Seismic data thus obtained, together with the instrumental data from Colombo, Dehra Dun and Hyderabad Observatories, thanks to the co-operation of the Directors of these Observatories, are collected and edited at the Meteorological Office, Poona. At Poona also are collected and edited the non-instrumental earthquake data reported from time to time. From January 1948 a monthly seismological bulletin has been issued, and the latest to be received is for December 1949. The greatest numbers of earthquakes felt by observers during December 1949 were three at Darjeeling and three at Tezpur, all having an intensity 5 on the Rossi–Forel scale.

Illuminating Engineering Society

MR. L. J. DAVIES, director of the Research Laboratory of the British Thomson-Houston Company, Ltd., has been elected president for 1950–51 of the Illuminating Engineering Society. The Leon Gaster Memorial Premium (of 10 guineas), which is for the best contribution published by the Society during the year, has been awarded to Dr. R. G. Hopkinson and Mr. P. Petherbridge (both of the Building Research Station, Garston, near Watford), for their paper entitled "Discomfort Glare in Relation to the Lighting of Buildings". The Silver Jubilee Commemoration Award (of 5 guineas) has been given to Mr. I. H. Hall, of Birmingham, for an essay entitled "Some Problems Associated with the Development of the Fluorescent Lamp". This is the first occasion on which this has been awarded for several years; it is open only to members of the Society under the age of twenty-five years for a paper on some aspect of illuminating engineering.

Public Works and Municipal Services Congress and Exhibition

THE Public Works and Municipal Services Congress and Exhibition for 1950 will be held in the Olympia, London, W.14, during November 13–18. The opening ceremony will be performed by Mr. Aneurin Bevan, Minister of Health and president of the Congress and Exhibition Council. A number of conferences, each one under the auspices of a particular organisation, have been arranged in connexion with the Congress, and these organisations are: the Association of Public Lighting Engineers, Institution of Municipal Engineers, Institution of Gas Engineers, County Surveyors Society, County Land Agents Association, Institution of Civil Engineers, Institute of Park Administration (Inc.), British Waterworks Association, Town Planning Institute, Institute of Sewage Purification, Institute of Public Cleansing and the Royal Institute of British Architects. Further details can be obtained from the secretary of the Public Works and Municipal Services Congress, 84 Eccleston Square, London, S.W.1.

Announcements

PROF. ANDRÉ MAYER, professor of natural history in the Collège de France, has been elected member of the Section of Rural Economy and Veterinary Practice of the Paris Academy of Sciences, in succession to the late Prof. R. Fosse.

MR. A. P. C. CUMMING has been elected to a Salters' Fellowship for research in chemical engineering during the year 1950–51.

MR. G. H. NOORDHOF has been appointed a lecturer in the Department of Education of the International Wool Secretariat. Mr. Noordhof is a graduate of the Universities of Cambridge and London, and has carried out research for the Department of Scientific and Industrial Research in the field of physical chemistry.

THE following appointments in the National Agricultural Advisory Service of Britain have recently been announced: Mr. H. L. Shrimpton, deputy chief livestock husbandry officer, to be chief livestock husbandry officer in the Service in succession to Mr. H. Twinch, who has retired; Mr. H. Trefor Jones, provincial soils chemist in the Yorkshire and Lancashire Province of the Service, to be deputy provincial director for the Yorkshire and Lancashire Province in succession to Mr. W. Weir, who has retired.

THE British Standards Institution has opened a branch office at 12 Hilton Street, Manchester, 1, in charge of Mr. A. F. B. Nall, an assistant technical director of the Institution (telephone: Central 4856; telegrams: Bristandin, Manchester). At this office a complete set of British Standards, some 1,600 in number, may be consulted and copies purchased.

THE fifth of the series of Oxford Management Conferences, under the auspices of the British Institute of Management (Management House, 8 Hill Street, London, W.1), will be held at Harrogate during November 16–19. Sectional meetings will be divided into two types: panel debate, in which broad issues will be considered, without advance circulation of the papers; and discussion sessions, in which specific issues will be discussed in considerable detail, with the idea of reaching definite conclusions, and in which the papers will be circulated in advance.

THE Royal Society of New Zealand is offering the T. K. Sidey Summer-Time Award, consisting of a bronze medal and a prize of £100 (N.Z. currency). This award is to be made primarily (though not necessarily) to a New Zealand citizen, or scientific worker in New Zealand, for research on light visible and invisible and other solar radiations in relation to human welfare, or on electromagnetic radiations of every kind. Further information can be obtained from the secretary of the Royal Society of New Zealand, Victoria University College, Wellington, New Zealand.

THE Sintered Oxides Sub-Committee of the Inter-Service Metallurgical Research Council (Ministry of Supply and Admiralty) has recently, in consultation with manufacturers, standardized the production of tubes of special refractory to two materials—impervious alumina and impervious mullite (for use up to 1,700° C.)—with eight sizes in the range of internal diameters 5–75 mm. and corresponding wall thicknesses of 1·5–5·5 mm. All standard tubes will be available in lengths up to 900 mm. with both ends open, or one open and the other hemispherically closed. At the same time a standard cross-section of impervious alumina twin-bore thermocouple insulator has been agreed upon.

ERRATUM. In the communication "Runs Up and Down on a Lattice" by Prof. P. V. Krishna Iyer in *Nature* of August 12, p. 276, for "Variance for (1) and (2) . . ." read

$$\left.\begin{matrix}\text{"Variance for}\\ \text{(1) and (2)}\end{matrix}\right\} = \frac{1}{90}\left\{16n(1^n) - 29(1^{n-1})\right\},$$

where (1^r) denotes the monomial symmetric function of degree r in $l_1, l_2, \ldots l_n$".

STATE OF HÆMOGLOBIN IN SICKLE-CELL ANÆMIA

By

DR. M. F. PERUTZ AND J. M. MITCHISON

Cavendish Laboratory and Molteno Institute, Department of Zoology, University of Cambridge

SICKLE-CELL anæmia is a congenital disease found among Negroes. It manifests itself in a reversible change in shape which the red cells undergo in response to changes in the partial pressure of oxygen, and which appears to lead to an excessive rate of red-cell destruction. In arterial blood these cells have the shape of normal biconcave disks, while in venous blood between 30 and 60 per cent of the cells assume the shape of sickles, holly wreaths or straight tubes. These reversible changes have been reproduced *in vitro* and described in detail, for example by Ponder[1]. Pauling *et al.*[2] showed that the hæmoglobin from sickle-cell anæmia patients has a different electrophoretic mobility from normal human hæmoglobin. They suggested that the disease may be caused by a change in the composition or structure of the hæmoglobin molecule, leading to molecular aggregation of hæmoglobin in the de-oxygenated state. However, more recently Pauling *et al.*[3] reported that no significant differences between the acidic and basic amino-acid contents of the two proteins could be found, and that the hæms were identical. Even more surprising was the observation that the differences in electrophoretic mobility disappeared when the hæms were detached from the globin, the mobilities of the globins being identical.

Sherman[4] observed that the 'sickled' cells were birefringent. Some months ago, Dr. C. A. Stetson, of the Rockefeller Institute, suggested to us that the actual process of 'sickling' bore some resemblance to crystallization, in that a structural change can be observed to spread through the cells from a focus. He supplied us with a small sample of anæmia cells, while Dr. F. Eirich, who had first directed our attention to this peculiar disease, gave us a sample of sickle-cell hæmoglobin solution.

Structure of 'Sickled' Cells

The red cells were suspended in 0·1 *M* phosphate buffer at *p*H 7 saturated with hydrogen sulphide, and sealed on a slide. The slides were examined under a polarizing microscope of high sensitivity developed by Swann and Mitchison[5]. Between crossed nicols, without compensation, the sickled cells lit up in a deep blue colour and became extinguished completely at every 90° rotation of the stage. In the case of the straight tubular cells, extinction was parallel to the length of the tubes. There could be no possible doubt about the birefringence of the cells. It should be added that normal red cells show no birefringence.

Introduction of an elliptical compensator produced the series of colour changes illustrated in Fig. 1. When the slow-vibration direction of the compensator was parallel to the length of the cells, their colour changed from deep blue to violet and finally to green; when the compensator was turned the other way, the colour changed to pale pink and white. The orientation of these effects was the same in all cells. The colours observed were totally different from the normal interference colours of birefringent crystals in polarized light, and were suspected to be due to the presence of crystalline reduced hæmoglobin in the sickled cells.

A crop of normal human reduced-hæmoglobin crystals of a size similar to that of the sickled cells was now prepared. Most of these crystals were prismatic needles of the type shown in Fig. 1 and corresponding to the crystals in Fig. 6 of Jope and O'Brien's work[7]. Between crossed nicols they showed a deep blue colour and straight extinction, just like the sickled cells. Introduction of an elliptical compensator produced the identical series of colour changes, with the long axis of the crystals corresponding in direction to the length of the cells. These observations indicated that the sickled cells did indeed contain crystalline reduced hæmoglobin, and that the needle axis of the crystals was parallel to the length of the cells.

The larger crystals had a marked dichroism, with the direction of strong absorption normal to the needle axis, which shows that the hæm groups are oriented roughly normal to the needle axis[6]. This indicates that these groups are also oriented normal to the length of the anæmia cells (Fig. 1).

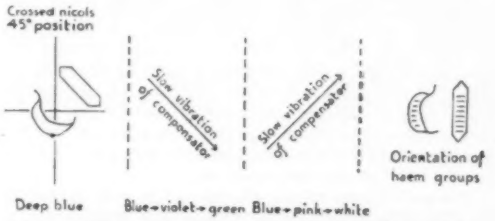


Fig. 1. Colours shown by sickled-cell and thin reduced hæmoglobin crystal between crossed nicols without and with compensation. The orientation of the hæm groups is indicated on the right

It was surprising to discover that some of the hæmoglobin had crystallized in the form of sickles apparently composed of a fan-like assembly of plates. The resemblance in shape between these crystals and the sickle cells was suggestive; on the other hand, the linear dimensions of the crystals were about ten times larger than those of the sickled cells.

Origin of the Anomalous Colours

This was investigated by measuring the dispersion of the birefringence of the reduced hæmoglobin crystals. The retardation of a thin crystal plate was measured at a series of monochromatic wave-lengths, using interference filters of band-width 0·015 μ made by the Farrand Optical Co. and kindly lent to us by Lord Rothschild. Fig. 2 shows the dispersion curve of a crystal over the visible spectrum; the light-absorption curve of reduced hæmoglobin in solution is plotted for comparison.

The relation between the two curves is readily understood if the theory of anomalous dispersion is applied to the case of a dichroic crystal. In accord-

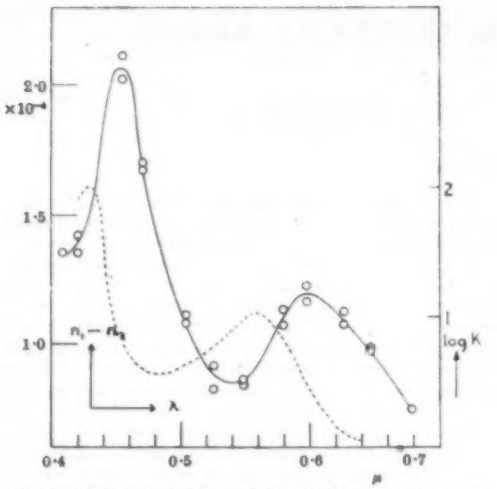


Fig. 2. Full curve: dispersion of the birefringence of normal human reduced hæmoglobin crystal (ordinate on left). The absolute birefringence scale is approximate, due to uncertainty of the crystal thickness. Dashed curve: absorption coefficient of human reduced hæmoglobin in solution[10] (ordinate on right)

ance with this theory, the refractive index of one plane-polarized ray, which is strongly absorbed, rises to a maximum on the long-wave side of each absorption band and drops to a minimum on the short-wave side of each band, while the refractive index of the other plane-polarized ray, which is not absorbed, is unaffected. Hence the retardation between the two rays rises and falls near each absorption band, just as observed. The birefringence should actually be reversed in sign, as the refractive index of the strongly absorbed ray should become negative on the short-wave side of absorption bands; evidently this is prevented here either by the contribution of the protein to the birefringence of the crystals or by the overlapping of the two maxima.

The anomalous colour effects can be well explained by the dispersion curve. Since the retardation is greatest in the violet and blue, very thin specimens will actually show a mixture of those colours. When a compensator is introduced in the subtraction position, retardation is only visible from the peak value in the violet. Further subtraction reverses the birefringence, so that the crystals now show the colours where their natural birefringence is least, that is, in the green.

Solubility of Hæmoglobin

There is a marked solubility difference between the reduced hæmoglobin of normal human blood and of blood from sickle-cell anæmia patients. The solubilities were measured at 20° C. in phosphate buffer at *p*H 6·8, prepared by mixing 0·58 and 0·42 mole fractions of dipotassium hydrogen phosphate and potassium dihydrogen phosphate respectively. The results are plotted in Fig. 3, which shows the solubilities of sickle oxyhæmoglobin and methæmoglobin to be normal within the limits of error. The solubility of normal human reduced hæmoglobin is about half that of the oxyhæmoglobin, in accordance with the findings of Jope and O'Brien[7]. The solubility of the sickle-reduced hæmoglobin, on the other hand, is no more than one-hundredth of that of the oxyhæmoglobin.

The differences between the solubilities were also found to be of the same order at physiological *p*H (7·3). They were found in both the samples provided to us, which came from different patients, and they were independent of the method of preparation of the proteins.

Discussion

The hæmoglobin in normal red cells and oxygenated sickle cells is almost certainly not crystalline. Such cells are not birefringent in plasma, and there is evidence that the hæmoglobin molecules are randomly oriented[8]. Our experiments, however, indicate that the reduced hæmoglobin in sickle-cells is in a crystalline state. These observations, taken together with the abnormally low solubility of the reduced sickle hæmoglobin, suggest a simple mechanism for the reversible changes in shape undergone by the anæmia cells. It appears as though on de-oxygenation the hæmoglobin crystallizes inside the red cell, and that on oxygenation it goes back into solution. The change in shape would be forced upon the cells partly by the habit of the crystals and partly by the loss of water which would be expected to accompany crystallization. For while red cells contain 34 per cent hæmoglobin, crystals contain between 50 and 60 per cent. The surplus water not enclosed in the crystals, being almost free of protein, would tend to diffuse out of the cells through loss in osmotic pressure, thus causing the cell membrane to collapse.

For the time being, this explanation must remain tentative, and far more work is needed to clear up the problem completely. In the first place, we should be more certain of our ground if the solubilities had been determined at physiological ionic strength, which could not be done for lack of material. Secondly, there is nothing to show, so far, that the pathological changes of the red cell in sickle-cell anæmia are confined to the hæmoglobin. Other differences both in the cytoplasm and in the cell membrane may well exist: this is suggested, for example, by the difference between the resistance to lysis of normal red cells and sickle anæmia cells, even in the oxygenated state of the hæmoglobins[9]. Thirdly, several hæmoglobins

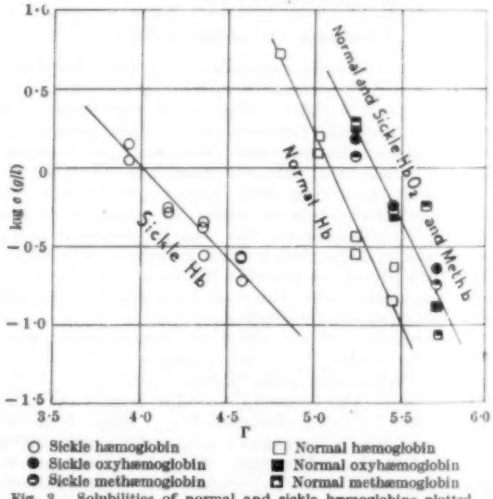


Fig. 3. Solubilities of normal and sickle hæmoglobins plotted against ionic strength of phosphate buffer. $\Gamma = \frac{1}{2}\sum_i c_i z_i^2$, where c_i is the concentration of each ion in moles/litre and z_i its valency

are known, for example, those of guinea pig or rat, which are extremely insoluble, but nevertheless normally exist in solution in the red cell. No one, in fact, has yet demonstrated the existence of crystalline hæmoglobin inside any kind of red cell *in vivo* or under strictly physiological conditions. Under non-physiological conditions it has been observed in many instances[11–16]. Owsjannikow described the crystallization of hæmoglobin inside the red cells of fishes, leading to elongation of cells. He also obtained crystals inside the red cells of rabbits, dogs, cats and guinea pigs[14]. Teitel Bernard[16] showed that the hæmoglobin in human red cells can be crystallized by immersing the cells in slightly hypertonic saline buffered to *p*H 6·5, and leaving them for some hours or days. The appearance of his cells suggests that they contain reduced hæmoglobin crystals of the form shown in Fig. 5 of Jope and O'Brien's work[7].

One of the most interesting problems emerging from this study is the great change in physico-chemical properties which hæmoglobin undergoes on combining with oxygen. This change may be exceptionally pronounced in sickle-cell anæmia; but similar, though often lesser, differences between reduced and oxyhæmoglobin have been found in all animal species so far investigated and are as yet totally unexplained.

We wish to thank Dr. F. Eirich and Dr. C. A. Stetson for bringing this interesting problem to our attention and for providing us with specimens, and Prof. D. Keilin for his valuable criticism. We are also indebted to the Medical Research Council for financing this work.

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WALDEN INVERSION AND REACTION MECHANISM

Walden Inversion in Unimolecular Reactions of Secondary and Tertiary Alkyl Halides

ONE of the rules, given in our papers of 1937 on the relation of the Walden inversion to reaction mechanism[1], was that unimolecular substitutions, S_N1, of alkyl compounds involve racemization with excess of inversion, the excess diminishing when conjugation increases the stability of the intermediate alkyl cation. The evidence underlying this conclusion was, however, complicated. It depended on results obtained with optically active secondary alkyl halides, the unimolecular reactions of which are often difficult to obtain in a pure form, even aqueous solvolysis, although largely unimolecular, involving an appreciable, but not closely estimated, bimolecular component. Tertiary alkyl halides, which readily undergo pure unimolecular reactions, were then unavailable in optically active forms.

We have now improved the basis of the rule, first by developing new methods for mechanistic analysis of the solvolysis of secondary halides, and secondly, by studying the solvolysis of an optically active tertiary halide.

The method of mechanistic analysis was outlined in 1946, as a proposal based on our then new knowledge of the conditions in which one may completely suppress bimolecular substitution, S_N2, by steric hindrance[2]. By using systems such as $(CH_3)_3C.CH_2.Cl$ and $(CH_3)_2C.CHMe.Cl$, one can secure the pure unimolecular solvolysis, S_N1, of even a primary and a secondary halide; the solvolysis of the related tertiary halide $(CH_3)_2C.CMe_2.Cl$ is, of course, unimolecular. By changing the state of alkylation of C_β, it has been confirmed that unimolecular substitution is not, as bimolecular substitution certainly is, subject to steric hindrance; and also that β-alkylation has no great polar effect; so that its overall kinetic effect on unimolecular substitution is small, as is illustrated by the following Arrhenius parameters (E in kcal., B in sec.$^{-1}$) for the solvolysis of RCMe$_2$Cl in 80 vol. per cent aqueous ethyl alcohol.

R	CH_3	CH_2Me	$CHMe_2$	CMe_3
E	23·1	22·9	23·3	23·8
$\log_{10}B$	11·9	11·9	12·0	12·5

On the contrary, α-alkylation has a large kinetic effect; and therefore, as regards unimolecular solvolysis, alkyl halides can be divided sharply into the three classes, primary, secondary and tertiary, each class having kinetic constants which are nearly independent of other details of the alkyl structure, though they do depend on the halogen and the medium. For example, we may set down E-values for bromides in 80 vol. per cent aqueous alcohol as follows:

Bromide	Primary	Secondary	Tertiary
E (kcal.)	30·0	26·7	23·3

Now when those simple halides are examined for which bimolecular solvolysis is not structurally precluded, it is found that the kinetic constants for the solvolysis of tertiary halides conform to type, but that those of the secondary and primary halides deviate from the relevant unimolecular values. That is because the solvolyses of these secondary halides are partly, and of the primary halides are very largely, bimolecular. From the kinetic constants given by the secondary halides, it is possible to estimate the proportions of the unimolecular and bimolecular reactions. We thus find, for example, that at least 75 per cent of the solvolysis of β-*n*-octyl bromide in 60 vol. per cent aqueous ethyl alcohol is unimolecular. The observed 66 per cent preservation of optical activity with inversion of configuration[1] is clearly more than could be credited to the bimolecular part of the reaction; and thus the conclusion is confirmed that unimolecular solvolysis entails an excess of inversion.

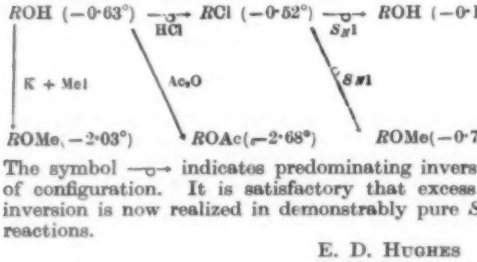
As a convenient source of optically active tertiary alkyl compounds, methylethyl*iso*hexylcarbinol was prepared by catalytic hydrogenation of linalool. The (−)alcohol was converted into the (−)chloride[3] through the agency of (*a*) hydrogen chloride, (*b*) thionyl chloride, (*c*) thionyl chloride and pyridine, and (*d*) phosphorus pentachloride, all general methods

which have been shown to produce inversion of configuration. It could not be established for any preparation of the chloride that no optical purity was lost; an attempt by our usual method of back-conversion in kinetically controlled bimolecular conditions (S_N2) was frustrated by a large incursion of olefin formation ($E2$). The (−)alcohol was converted, through its potassium salt and methyl iodide, into the (−)methyl ether, and, with the aid of acetic anhydride, into the (−)acetate, reactions which leave untouched the asymmetric centre. It follows that the (−)alcohol, the (+)chloride, the (−)methyl ether, and the (−)acetate have corresponding configurations.

The hydrolysis of the chloride in 80 vol. per cent aqueous acetone was followed kinetically (k_1 at 60°, $1{\cdot}58 \times 10^{-4}$ sec.$^{-1}$), and shown to be unimolecular; it could not be appreciably accelerated by added alkali. Under mildly alkaline conditions, the (−)chloride gave a (−)alcohol with 21 per cent of the optical activity of the original alcohol, and therefore at least 21 per cent of the activity which would have resulted from a completely non-racemizing hydrolysis. The alcohol was shown to be optically stable under the conditions of its production.

The alcoholysis of the chloride in anhydrous methyl alcohol was shown to be unimolecular (k_1 at 60°, $2{\cdot}74 \times 10^{-4}$ sec.$^{-1}$), added sodium methoxide producing only a slight acceleration. Under mildly alkaline conditions, the (−)chloride gave a (−)ether with 34 per cent of the activity of ether prepared by methylation of the original alcohol, and therefore at least 34 per cent of the activity which would have resulted from a non-racemizing alcoholysis. The ether was optically stable in the conditions of its production, though it was rapidly racemized in acidic methyl alcohol.

The rotations indicated below ($\alpha_D^{17°}$, $l = 10$) were measured in the experiments mentioned:



The symbol —○→ indicates predominating inversion of configuration. It is satisfactory that excess of inversion is now realized in demonstrably pure S_N1 reactions.

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Walden Inversion in the Acid Hydrolysis of Carboxylic Esters by Unimolecular Alkyl Fission

One of the less thoroughly investigated of the seven mechanisms of carboxylic ester hydrolysis, which Day and Ingold listed and associated with observed or predicted structural, kinetic and stereochemical characteristics[1], is the acid-catalysed, unimolecular reaction involving alkyl-oxygen fission, $-A''1$ as they labelled it, or $A_{AL}1$ as we now prefer to write:

$$R'\mathrm{CO.O}R \overset{\text{fast}}{\rightleftharpoons} R'.\overset{+}{\mathrm{C}}\mathrm{O.OH}R \overset{\text{slow}}{\rightleftharpoons} R'\mathrm{CO_2H} + R^{+} \overset{+\text{ fast}}{\rightleftharpoons} R\,\mathrm{CO_2H} + R\mathrm{OH} \quad \ldots \quad (A_{AL}1).$$

This mechanism was expected to be easily realizable when R was a tertiary alkyl group. Having an optically active tertiary alkyl acetate in our hands (see preceding note), it was an obvious task to set up the conditions for $A_{AL}1$ hydrolysis, and to verify the stereochemical course of the process.

The base-catalysed hydrolysis of methylethyl*iso*hexylcarbinyl acetate was first examined. The reaction with 0·02–0·04 N sodium hydroxide in 64 vol. per cent aqueous dioxan had the kinetic form: rate $= k_2$ [ester] [$\bar{\mathrm{O}}$H] (with $k_2 = 2{\cdot}82 \times 10^{-3}$ sec.$^{-1}$ gm.-mol.$^{-1}$ l. at 90°). The alcohol produced had a retained configuration and 99 per cent of its original optical activity. Obviously this is the usual base-catalysed, bimolecular reaction with acyl-oxygen fission, $B_{AC}2$:

$$R'\mathrm{CO.O}R \xrightarrow[\text{slow}]{} R'\mathrm{C}(\bar{\mathrm{O}})(\mathrm{OH}).\mathrm{O}R \xrightarrow[\text{fast}]{} R'\bar{\mathrm{C}}\mathrm{O_2} + \mathrm{HO}R \quad \ldots \quad (B_{AC}2).$$

The acid hydrolysis with 0·01–0·06 N hydrogen chloride in 70 vol. per cent aqueous acetone had the kinetic form: rate $= k_2$ [ester] [$\overset{+}{\mathrm{H}}$] (with $k_2 = 10{\cdot}4 \times 10^{-3}$ sec.$^{-1}$ gm.-mol.$^{-1}$ l. at 76·1°). Samples of alcohol recovered from hydrolyses with 0·02 N hydrogen chloride had predominantly inverted configurations, and 9–12 per cent of the maximal optical activity. It has to be taken into account that the alcohol itself undergoes racemization in these acid solutions. The rate of this process having been determined, it was computed that the alcohol, as freshly produced by hydrolysis, had about 19 per cent of its maximal activity.

The following rotations ($\alpha_D^{17°}$, $l = 10$) were measured in these experiments:

$$R\mathrm{OH} \xrightarrow{\mathrm{Ac_2O}} R\mathrm{OAc} \begin{cases} \xrightarrow{\bar{\mathrm{O}}\mathrm{H}} R\mathrm{OH}\ (-0{\cdot}62°) \\ \xrightarrow{\overset{+}{\mathrm{H}}} R\mathrm{OH}\ (+0{\cdot}06° \text{ to } +0{\cdot}08°). \end{cases}$$

$$(-0{\cdot}63°) \quad (-2{\cdot}68°)$$

Evidently the acid reaction is producing racemization with some excess of inversion, as would be expected from the presumed mechanism and the general rules governing the stereochemistry of substitution. The smallness of the resulting activities shows that acid-catalysed bimolecular alkyl-fission (mechanism $A_{AL}2$) is either absent, or present to only a small extent.

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EIGHTEENTH INTERNATIONAL PHYSIOLOGICAL CONGRESS

THE Eighteenth International Physiological Congress met at Copenhagen during August 15–18. It was attended by more than 1,200 members who contributed some six hundred communications. To accommodate these numbers was a formidable undertaking, and it was generally felt that the organisers had managed to perform their task smoothly and with admirable efficiency. When opening the Congress, Prof. E. Lundsgaard paid a tribute to the memory of the late Prof. August Krogh, and somewhat diffidently referred to the fact that he himself was presiding only as a substitute; but at the end there was little doubt that he and his helpers, particularly the general secretary, Prof. P. Brandt Rehberg, had excelled themselves in managing the affairs of the Congress, and the gratitude of members was well expressed by the applause with which Prof. Lundsgaard was greeted when he made his final appearance.

There were seven half-day business sessions, four of which were reserved for the presentation of individual short papers, while three were devoted to "General Discussions" of selected problems. To distribute the load, the proceedings were divided into several simultaneous sections: two or three general discussion meetings were held at a time, and individual papers were presented in ten different halls, where each paper had to be read and discussed in fifteen minutes. It is, therefore, impossible for any one person to report on more than a small fraction of the transacted programme. The present writer's main interest lies in the field of nerve and muscle function and the properties of excitable cell membranes, so that he found no time to attend discussions on other matters, and even had to miss some important contributions within his own narrow field of interest.

The session which stands out most in the writer's memory was a discussion on the transport of substances across cell membranes, in which important papers were read by Prof. E. J. Conway, H. H. Ussing, and A. L. Hodgkin and A. F. Huxley. The authors dealt with such different subjects as fermentation in yeast cells, secretion of the gastric mucosa, transport of salt and water across frog skin, and ionic exchange mechanism during the nerve impulse. In spite of the different materials and methods of approach which the authors had chosen, it was interesting to observe that they tended to arrive at a common postulate, namely, the existence in the cell membrane of 'carrier-substances' with specific affinities for certain cations. These substances may be thought of as specific reversible acceptors for potassium, sodium or hydrogen, and it appears that the functional activity of the cell depends upon some form of 'activation' or 'mobilization' of these cation-carriers. But apart from these speculative ideas, a wealth of quantitative information was presented on the movement of individual species of ions across membranes and the extent to which their movement can be controlled by chemical and electrical potential gradients. The audience was particularly impressed by the argument of Hodgkin and Huxley, who supplied precise figures on the movement of sodium and potassium ions across the nerve membrane and concluded that the transfer of these ions is responsible for the electric currents by which nerve impulses are transmitted. In the normal resting nerve cell, no net entry of sodium occurs, in spite of the high inward gradient of its electro-chemical potential. But it appears that a large surge of sodium current, in the direction of this gradient, occurs when the cell membrane is suddenly depolarized. This transient state of rapid sodium transfer is followed by a maintained state of rapid potassium outflux. Hodgkin and Huxley showed that the magnitude and direction of the 'sodium surge' can be controlled, in a theoretically predictable manner, by varying either the potential, or the sodium concentration, gradient across the membrane. On the basis of these findings, it is possible to explain and to reconstruct the events which take place during excitation and the propagation of nerve impulses. The immediate source of energy which is utilized during the transmission of the impulse appears to be the thermal energy of sodium and potassium ions, and active metabolic processes are only called upon slowly to restore and maintain the electro-chemical gradients of the resting cell. During the discussion which followed, Prof. von Muralt paid a generous tribute to the high quality and importance of this work, and the audience gained the same impression during a later session in which A. L. Hodgkin and R. D. Keynes showed some elegant and decisive ways of employing radioactive tracer techniques in a study of ionic movements in nerve axons. As a by-product of this work, direct proof is now available to show that the activity and mobility of potassium ions in the nerve axoplasm is equal, or nearly equal, to that in an aqueous solution.

Among other papers which impressed the writer as new and very important was H. H. Weber's contribution to the discussion on muscle function, in which he showed that the actomyosin – adenosine triphosphate system resembles contracting muscle much more closely, in its mechanical properties, than was previously believed.

There were many other important contributions, both during the discussion meetings, and the sessions in which individual papers were presented. A symposium on the thermodynamics of muscle was opened by Prof. A. V. Hill, followed by A. Szent-Györgyi. The factors affecting cardiac output in man were discussed by A. Cournand, J. McMichael and G. Nylin. Profs. C. H. Best and B. A. Houssay introduced a conference on the hormonal control of fat metabolism, and the properties of the retina were reviewed by Drs. R. Granit, H. J. A. Dartnall and Prof. H. Hartridge. A discussion of the principles of spinal cord activity was introduced by F. Bremer, D. P. C. Lloyd and C. G. Bernhard, and a session concerned with the problems of salt and water excretion was opened by H. W. Smith and E. B. Verney.

In certain sections (for example, those dealing with nerve and muscle function, and with general cell physiology) a good deal of new information was reported which depended upon the recent adaptation of two methods: first, the use of radioactive isotopes in studying the properties of cell surfaces, and secondly, the use of the intracellular recording electrode introduced some years ago by R. W. Gerard.

Inevitably, the papers which have been mentioned here represent only a very narrow selection of the large amount of important material that was presented.

Most members appeared to be very well satisfied with the friendly spirit and the interesting results of this Congress; but many of them must have pondered over the problems posed by the heavy and increasing

weight of numbers at such international gatherings. Some further experimentation along the line of 'general discussion meetings' would seem to be required, though many such meetings suffer from the fact that too much time is taken up by long 'introductory' papers which leave little opportunity or desire for general discussion afterwards. To achieve a more vivid interchange of ideas and information, it might perhaps be better to have at each session a single introductory review followed by informal discussion. It would also seem that such sessions require some preparatory work by which the organiser approaches individual colleagues in his field to ensure an adequate response.

It is perhaps doubtful whether there remains very much use for sectional sessions in which large numbers of individual papers follow one another, often with little or no connexion and little or no time for questions. If it is felt desirable to retain such sessions, members might at least be discouraged from including papers which have already been published in full. But criticisms such as these are a very minor matter compared with the good that comes from personal contact and the great stimulus that everyone can derive by challenging in private session his scientific friends and opponents.

At the closing session an invitation was received and warmly welcomed to hold the next, the Nineteenth International Physiological Congress, at Montreal in 1953.

CONGRESS OF THE INTERNATIONAL ASSOCIATION FOR THE PROTECTION OF INDUSTRIAL PROPERTY

THE resolutions passed at the Congress of the International Association for the Protection of Industrial Property, held in Paris during June 1950, which have now been published, assume a wider significance in view of the measures being taken in other directions to effect the economic integration of Europe. The Association is an informal body comprising industrialists, patent agents, solicitors and barristers who are directly concerned with questions relating to inventions, patents, trade marks and copyright. The expression "Industrial Property" is a convenient portmanteau phrase for describing commercial rights connected with international trade and industry in these matters.

The conception of a uniform international law in the limited field of industrial property is old. The Association was formed in the seventies of the past century with the object of remedying the insuperable difficulties which then faced a manufacturer or trader in one country in securing protection for his inventions or trade marks in foreign countries.

Prior to 1883, there were a number of bipartite treaties entered into between various countries which specifically dealt *inter alia* with the protection of industrial property rights. In 1883, however, an International Convention for the Protection of Industrial Property was concluded in Paris, which laid down certain general principles to be applied by the member States in the manner best suited to their own systems of legislation so as to facilitate international trade and to prevent all kinds of unfair trading. The Convention has been periodically revised, the last revision having been undertaken at a diplomatic conference in London in 1934.

The resolutions passed at the recent Congress of more than four hundred delegates from about forty countries are to be submitted to the Governments of all these countries, as the next revision of the Convention is due to be undertaken at a diplomatic conference in 1951. A summary of the more important resolutions which were passed unanimously is given under the three headings of general resolutions, resolutions dealing with patents, and resolutions dealing with trade marks, as follows.

General Resolutions. The Congress proposed the adoption in the Convention of an Article that "any dispute between two or a number of Convention countries concerning the interpretation or the application of the general Convention and of the restricted Conventions which is not settled by negotiation shall be referred to the International Court of Justice [at the Hague] for decision by the latter, unless the countries in question agree upon another method of settlement". In order to prevent the exercise of the power of the veto by one country in suppressing amendments to the Convention, it was resolved that there should be incorporated in the Convention and in the arrangements depending on it the declaration that all amendments approved by at least four-fifths of those voting should be adopted.

Resolutions dealing with Patents. A number of amendments dealing with priority rights in connexion with patents and designs were adopted. Thus, at any time up to the final grant of his patent, an applicant should have the right to divide his application, preserving for his new application the benefit of his original application.

Again, failure to work in a Convention country an invention which is the subject of a patent granted in that country, or the introduction by the patentee into that country of objects manufactured in another Convention country, shall not lead to revocation of the patent. However, in order to prevent abuses which might result from the exercise of the exclusive right conferred by the patent, each Convention country shall be entitled to impose legislative measures providing for the grant of compulsory licences to any qualified applicant. In no case should a compulsory licence be asked for before five years from the date of the application of the patent or three years from the grant, whichever shall be the longer. The grant of a licence should be refused if the patentee can legitimately justify his failure to work the invention. A resolution was adopted proposing a new measure to the effect that patents or certificates of addition shall be freely convertible into principal patents on the application of the patentee.

It is interesting to note that many of these amendments will have the effect of bringing many articles of the Convention more into line with the domestic patent law in Great Britain as set out in the Patent Act of 1949.

Resolution dealing with Trade Marks. The resolutions in regard to trade marks were probably of more immediate and of wider importance to present conditions of international trade. Questions relating to the assignment and licensing of trade marks have caused considerable commercial difficulties. The function of a trade mark is not to indicate ownership, but rather to guarantee that goods bearing a trade mark have certain standards of quality. The recognition of free assignability and licensing of trade

marks is particularly necessary in international trade to-day where the owner must part with the title or use of his trade mark in order to be able to make it available in another country.

The Congress passed a resolution that the principle of free assignment of trade marks should be adopted by all Convention countries, subject to such limitations as the domestic law of each country requires to prevent deception of the public by the transfer of the mark. A further resolution was passed embodying the principle that persons other than the registered owner may use a trade mark provided that effective control of the use could be ensured by the proprietor, and subject again to such limitations as the domestic law of each country required, so as to prevent the use from deceiving the public.

Several other resolutions of lesser importance dealt with the prevention of unfair trading. When goods have been sold under a trade name which is a word in the vernacular of one of the countries, it may happen that a trader in another country may attempt to market similar goods in that foreign country under the name which is a translation of this word. This practice causes great difficulties and frequently leads to deception of the public. These difficulties would be overcome by the adoption of the principle that the Convention countries will accept and register, in one and the same operation, composite trade marks comprising the mark in the language of origin and its translation into other languages, each element of the composite mark being protected in itself.

These resolutions were supported in principle at the Conference of the International Bar Association held in July in Great Britain.

The adoption of these resolutions at the diplomatic conference of Governments will be a great step forward to the end that problems of international law in regard to industrial property may receive uniform solution in all countries which are party to the International Convention. R. G. Lloyd

ELEVENTH INTERNATIONAL CONGRESS OF THEORETICAL AND APPLIED LIMNOLOGY

THE Eleventh International Congress of Theoretical and Applied Limnology held in Belgium was attended by about eighty people representing seventeen different nations; but, despite the small number of participants, the vigorous exchange of opinion between all and sundry was a testimony to its great value. At the opening session, held in the fine assembly hall of the University of Ghent on the evening of August 16, the members were addressed by the president of the International Limnological Association (Dr. Gunnar Alm) and heard a lecture by the chairman of the Organising Committee (Prof. P. van Oye) on "The Beginnings of Limnology in Belgium". The six scientific sessions, at which upwards of forty papers on a wide range of topics were read, were held in the four university towns, Ghent, Brussels, Louvain and Liège, between August 17 and 23. Among many noteworthy contributions special mention may be made of those by Dr. Thomas (Zurich) on the nature of the monthly sediments deposited in certain Swiss lakes, by Dr. C. H. Mortimer (Windermere) on water movements in stratified lakes, by Prof. W. Rodhe (Uppsala) on a method of sampling and analysis of lake waters by ion exchangers, by Dr. M. Lefèvre (France) on antagonisms between successive populations of freshwater algæ, by Prof. d'Ancona (Padua) on the changes induced by the environment on the marine plankton in the lagoons of Venice, and by Prof. Lenz (Plön) on problems concerning chironomid ecology, the last in particular leading to a lively discussion.

On the Sunday afternoon a visit was paid to the Congo Museum at Tervuren near Brussels, where the members of the congress were entertained to tea by the Director and his wife. Similar hospitality was afforded us on several other occasions. In the course of the journey from Brussels to Louvain the large centre for fish-culture at Linkebeek was visited under the guidance of the director of applied limnology, Dr. M. Huet, who also led a three-days tour of south-east Belgium during August 24–26, comprising visits to the principal rivers, to the Michel dam, to the thermal establishment at Spa, and to the grottoes at Han. At the concluding session held at Liège on August 23, a committee consisting of Drs. Mortimer, Ohle and Rodhe was appointed to study and co-ordinate and, if needs be, initiate, new methods for hydrobiological investigation. The next congress will be held in Cambridge during August 1953.

F. E. Fritsch

AIRCRAFT-LANDING AIDS IN BAD VISIBILITY

AT a meeting held at Birmingham on September 5 of Section A (Mathematics and Physics) of the British Association, Mr. E. S. Calvert presented a paper entitled "Visual Aids for Landing in Bad Visibility, with Particular Reference to the Transition from Instrument to Visual Flight". Mr. Calvert said that during the past five years radio approach aids have been installed at all major airports to enable aircraft to land in conditions of bad visibility or low cloud. By means of these aids a pilot who is adequately trained in instrument-flying can align his aircraft with the runway and bring it down to a height of about 200 ft. without seeing the ground. The rest of the approach and landing, however, have to be made visually, and this means that the pilot has to make a rapid transition from instrument to visual flight when near the ground. At 200 ft. the aircraft is still about three-quarters of a mile from the end of the runway, and to bridge this gap a pattern of lights about 1,000 yd. long is laid down in the approach area. This pattern must be such that a pilot seeing only a portion of it can determine the aircraft's attitude, position and direction of motion, and the rates at which these are changing. The lights must be suitable for use by day as well as by night, and for this reason have to be of high intensity. The intensities being used at present are of the order of 100,000 candles.

During the radio portion of the approach, the pilot obtains his positional information either by listening to a voice in his earphones, or by looking at a meter on his instrument panel. From this he has to find the heading which will bring him on to the runway, a task which is particularly difficult when there is a cross-wind which varies with height. He also has to watch his flight instruments and manipulate the controls. His mind is therefore fully occupied when he sees the lights, and transition from instrument to

visual flight is difficult. If he makes the transition at 250 ft., then he will be flying on visual references for only 30 sec. prior to touch-down. With improved instrumentation the aircraft could perhaps be brought down to 100 ft., in which case this time would be reduced to 15 sec. The problem is, therefore, to find a pattern for the approach lights which will provide indications which the pilot can interpret instantly without having to use mental processes different from those which he has learnt to use in good-weather flying.

The first patterns to be tried consisted of single and multiple lines parallel to the extended centre-line of the runway, and these were followed by vees and funnels. Flight tests on these patterns extending over several years showed that in bad visibility the impressions of the pilot when he first picks up the lights often fail to correspond with the real situation. In other words, his first impressions are often illusions. Three illusions are commonly reported as follows: (1) The runway lights appear to 'float in space', or 'stand on end', that is, they appear as an inverted vee in the vertical plane instead of a pair of parallel lines in the horizontal plane. Also the pattern has 'no depth' and appears to be at a varying distance. As a result the pilot 'loses his ground plane' and has a strong impulse to pull up. (2) The approach lights appear to 'swing from side to side' or 'drift out of the field of view', so that instead of descending on a straight course, the pilot 'weaves' from side to side. (3) A strong impression of the horizon is suddenly built up in the pilot's mind, although he knows that he cannot tell where the horizon is without referring back to his instruments. When the pilot is suffering from fatigue or is in a state of mental stress, this conflict causes feelings of confusion and frustration, and in extreme cases of vertigo.

These illusions have been studied statically by means of perspective diagrams, and kinematically by means of landing simulators. It was found that when the effect of fog is simulated by removing the horizon, the visual indications become geometrically indeterminate. In other words, the same picture represents a large number of different situations. If, therefore, a pilot tries to correct an error by observing only the visual indications, he can scarcely avoid being confused by their ambiguity.

Mr. Calvert then showed that the indications can be made geometrically determinate by using a pattern consisting of a line of lights along the centre-line with bars of lights running transversely across it at intervals. The reason for this is that the bars supply the indication of the horizontal which is missing in the other patterns. This pattern, which is now known as the 'crossbar system', was installed at London Airport in November 1948, and shortly afterwards about a dozen installations were laid down in Germany, mostly for the 'Berlin Air Lift'. All reports agree that the transition is consistently easy and safe, and no illusions have been reported.

Mr. Calvert then described a new theory of visual judgment which has been developed as a result of collaboration between Capt. Majendie of B.O.A.C. and his own group at the Royal Aircraft Establishment. This theory, which is known as the 'parafoveal streamer theory', is briefly as follows. When the aircraft is several miles from the runway the angular subtense of the pattern and the rate of change of the perspective image are small, and the pilot makes his judgments by scanning the pattern and comparing the perspective image with an ideal one which he carries in his memory. As the aircraft comes closer to the pattern, its angular subtense and the apparent velocity of the lights increase. At about 150 ft. the pilot begins to stare straight ahead with his head and eyeballs fixed. After this, he derives his impressions of height and direction of motion mainly from the pattern formed by the paths which the retinal images of the lights trace out on the parafovea, and from the velocity of the images along these paths. These paths may be called 'streamers', the pattern a 'streamer pattern', and the image velocity the 'streamer velocity'. The reason why the pilot stares is that it is easier to judge streamer patterns and streamer velocities if he keeps his eyeballs fixed, because in that case the only changes in the retinal image are those due to changes in the streamer pattern and streamer velocities.

Capt. Majendie opened the discussion by showing a film which he had taken of the faces of various pilots when making landings. These showed clearly that at heights below about 150 ft. the pilot's head is rigid, and the eyes are staring straight ahead, except for occasional quick glances at an instrument or an obstruction. The film also showed some calibrated eye-movements which indicated that a movement of 1° could just be detected.

Mr. Glenny then showed some films of landings in very bad visibility which had been made in America by the Sperry Gyroscope Co. These also showed a high degree of fixated vision at low heights. A noticeable feature of both films was the expression of strain on the faces of the pilots.

Mr. Parker, speaking on behalf of the Ministry of Civil Aviation, said that the 'crossbar system' at London Airport has been very successful. During the past two winters many landings with passengers have been made on it in visibilities as low as 300 yards. The principles on which it is based are now generally accepted in Great Britain, and are being increasingly accepted abroad. It is one of three systems recommended by the International Civil Aviation Organisation, and about eight foreign countries are already installing it at their major airports. It is therefore quite possible that the 'crossbar system' will become the standard approach lighting system of the future.

PERIODIC FLUCTUATION IN THE LENGTH OF THE DAY

A PAPER by H. F. Finch "On a Periodic Fluctuation in the Length of the Day"[1] gives a full account of the performance of a number of quartz-crystal clocks employed in the Greenwich Time Service. Soon after the introduction of quartz clocks, their errors on a long-term basis were predicted, and the clock correction E was represented very closely by the expression $E=a+bt+ct^2$, where t is reckoned in time from some arbitrary epoch, and a, b, c are constants the values of which were derived from a series of time determinations extending over many months.

By applying the adopted current corrections to the standard clocks and using daily intercomparisons, it was possible to deduce the amount of correction for the clock controlling the time signal, prior to transmission. Although the method succeeded for a time, in the autumn of 1945 the observed clock corrections began to diverge from those predicted, the clocks

appearing to have undergone an acceleration of rate, and a retardation in the period of rotation of the earth was suspected. In subsequent years, as more clocks became available, the same phenomenon was in evidence, but it was not until the spring of 1949 that a definite retardation among a number of clocks was noticed. The suspicion of a seasonal fluctuation in the earth's period of rotation led to an examination of the final corrections to the times of emission of the Rugby time signals which are under the control of the Greenwich Time Service, and a full account of the investigations and the conclusions is given in Finch's paper.

It appears that there is a variation of the order 0·001 sec. and an accumulative effect in time of approximately 0·060 sec. Similar results were obtained by N. Stoyko[2], who published his investigations during 1936–37, but his work did not receive much attention at the time. An attempt to account for the phenomena of the slowing of the earth in spring and of its acceleration in the autumn was made by van den Dungen, Cox and van Miegham[3], who used observations of the barometric pressure over the surface of the earth at different seasons. They showed that the effect could be accounted for in part by changes in the earth's moment of inertia due to seasonal changes in the distribution of air masses, but owing to incomplete data further investigation is required.

It may be pointed out that Chapter 5 of "The Atmospheres of the Earth and Planets", edited by Prof. G. P. Kuiper, deals with the work of Whipple, Jacchia and Kopal on seasonal changes in the upper regions of the atmosphere. The whole upper atmosphere at a height of about 78 km. appears to rise in spring by 8 or 9 km. and to drop again by the same amount in the autumn. No reference is made in Finch's paper to this phenomenon, which may have to be taken into account in future explanations of the seasonal changes in the earth's rate of rotation. The fluctuation of approximately annual period in the mean longitude of the moon, deduced from occultation observations, is much too large to be explained by the variations in the rotation of the earth.

[1] *Mon. Not. Roy. Astro. Soc.*, **110**, 1 (1950).
[2] *C.R. Acad., Paris*, **203**, 39 (1936); **205**, 79 (1937).
[3] *Bul. Cl. Sci. Acad. roy. Belgique*, **5**, Series 35 (1949).

PACIFIC SCIENCE BOARD

ANNUAL REPORT FOR 1949

THE third annual report of the Pacific Science Board, covering the year 1949*, reviews briefly the work of the Seventh Pacific Science Congress, which was convened at Auckland and Christchurch during February 2–22, 1949; the Congress was attended by representatives of twenty-four countries, and more than five hundred papers were presented. Plans are now well advanced for the publication of the proceedings of the Congress, and the present report lists some articles describing the work of the Congress in general or in specific fields.

The Co-ordinated Investigation of Micronesian Anthropology programme consisted largely of continuing work by the participants on their final reports, of which twenty-six have now been accepted by the Board. The titles of these are listed in the report of the Board, and the reports are expected to be published by the sponsoring institutions or in appropriate scientific journals. The proposal to appoint three anthropologists to the staffs of the civil administrators in the Palau, Truk and Marshall Islands could not be implemented in 1949; but five anthropologists are already used by the United States Navy in its Civil Administration Units in the Trust Territory. The programme was extended in March 1949 to include other fields of science and is known as Scientific Investigations in Micronesia. Ten participants were appointed to carry out field work in the Trust Territory in anthropology, linguistics, botany and zoology.

The Insect Control Committee for Micronesia has sponsored a detailed study of *Achatina fulica* in various islands in the Trust Territory with the view of determining the variation in populations, extent of damage to crops, local predators, etc., and has sent a technician to investigate the possibility of processing it for human or animal food. Reports have been received that the wasp, *Scolia ruficornis*, that preys on the rhinoceros beetle (*Oryctes rhinoceros*) has become well established in western Samoa. Under the Conservation Committee for Micronesia, problems of the trochus shell (*Trochus niloticus*) fishery and of the robber or coconut crab (*Birgus latro*) have been investigated, as well as the damage to water supply and agricultural land resulting from mining operations on Angaur in the Palaus.

As a result of a report by Dr. C. J. Fish with Mary C. Cobb on "Noxious Marine Animals of the Central and Western Pacific", the Pacific Science Board has been requested by the United States Office of Naval Research to consider the preparation of a handbook that could be used by those stationed in the area on poisonous and otherwise dangerous animals in the Central and Western Pacific. Prospects for the realization of the high purpose of furthering scientific research in the Pacific through the agency of the Pacific War Memorial, which was established as a scientific foundation dedicated as a living memorial to those who served with the Armed Forces of the United States in the Pacific, depend on the availability of substantial support which has not yet materialized. Details of the Fulbright programme are included in the report, as well as a summary of the initial programme of the South Pacific Research Council for 1949–50.

Field projects approved by the Board include a Pilot Nutrition Study in Micronesia, with special reference to children, a mid-Pacific oceanographic project, a serological survey of the Pacific area, an anthropological and ethnographical study of the Southern Rynkyn Islands, a botanical study of New Caledonia, a filariasis survey of Tahiti, a study of diabetes mellitus in Guam, an anthropological and archæological survey of Saipan and an ethnological study of the Gilbert and Ellice Islands. Substantial progress is being made through the co-operation of the United Nations Social and Economic Council and its specialized agencies in awakening countries of the Pacific Area to the urgent need for taking measures to conserve their renewable natural resources. During the year the executive secretary of the Pacific Science Board visited the French Institute of Oceania, at Noumea, which it is hoped will increasingly become a base for international co-operative research in various fields of science.

* Pacific Science Board. Third Annual Report, 1949. Pp. 154. (Washington, D.C.: National Research Council, 1950.)

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Photo-electric Measurements of the Density of Tracks in Nuclear Emulsions

GRAIN-COUNTING is an important method for the study of charged particles in photographic emulsions. The method is well suited for the Ilford *C* 2 emulsion and others of a similar kind, but does not work for heavily ionizing particles in electron-sensitive emulsions, for example, the Ilford *G* 5. We have measured the density of the tracks in such cases by a photo-electric method.

A slit was mounted in the eyepiece of a microscope and the divergent light passing through the slit was allowed to fall on the cathode of a photo-multiplier tube (*RCA* 1 *P* 21). A portion of the track was adjusted symmetrically in the slit and the resulting photo current measured in terms of the current without track. Figs. 1 and 2 give the results of such measurements for 55 tracks from *G* 5 plates exposed during a balloon flight to an approximate altitude of 20 km. The length of the slit corresponds to 30 μ of track-length.

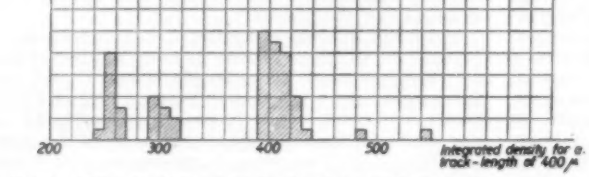


Fig. 1. Histogram of integrated densities for a track-length of 400 μ of 55 tracks in Ilford *G* 5 emulsion

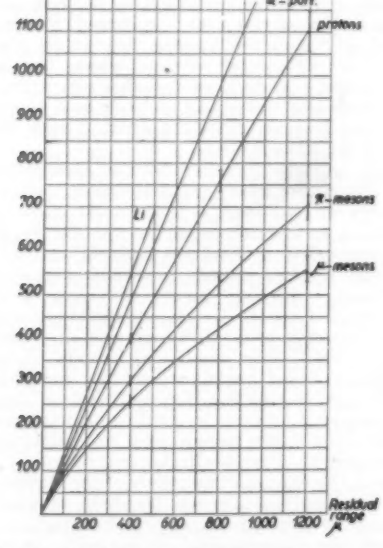


Fig. 2. Integrated density in arbitrary units against residual range for tracks in Ilford *G* 5 emulsion

The diagrams show that it is possible to distinguish with certainty between π- and μ-mesons. The limits of error indicated in the diagrams cover all measured values. The method is also well suited for tracks from heavy particles.

A detailed account of the method and of results obtained will be given elsewhere.

STEN VON FRIESEN
KRISTER KRISTIANSSON

Physics Department,
University of Lund.
June 16.

Production of Uniform Droplets

A SIMPLE apparatus has been evolved which will generate lines, or streams, of droplets. All those in one stream are of the same size and follow the same trajectory, but differ from those in another stream. Primary and subsidiary droplets are formed, and, by adjustment, diameters ranging from 10 μ to 300 μ may be obtained. The production of the droplet system is regular, and may be watched in slow motion if illuminated by a stroboscopic light source.

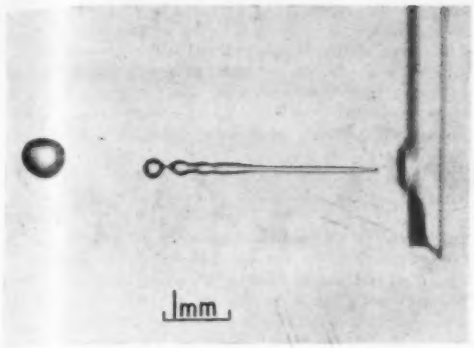
The basis of the apparatus is a vibrating hollow reed supplied with liquid. A length of ordinary glass tubing 3/16 in. or $\frac{1}{4}$ in. outside diameter is drawn to a fine capillary of about 0·025 in. outside diameter and up to 8 in. long. On to this reed is waxed a short piece of 1 or 1·5 mm. steel hypodermic tubing an inch or two from the shoulder, to act as an armature. A mounting is now necessary to clamp the butt of the capillary firmly and to support a small electromagnet, aligned with the armature, and energized by an alternating current. The mains supply via a transformer is suitable for this.

With liquid supplied to the butt of the hollow reed (only a small head is needed), and the electromagnet switched on, the capillary is tuned to resonance with the applied frequency by shortening it in steps of about 1/16 in. The tip of the reed will then sweep a path varying from a straight line to a circle depending apparently on the cross-sectional form of the capillary and its alignment with the magnet. Thus by arranging for the position of the magnet to be adjustable, and by twisting the reed in its clamp, a wide variation may be obtained.

Streams of droplets are thrown off at various points on the path of the reed tip, usually at points of maximum acceleration.

A cylinder provided with an aperture, and surrounding the vibrating tip, enables a single stream of drops to be selected. The axis of the capillary may be at any angle provided the tip is below the butt.

A series of photographs was taken over a period of 15 min. showing the stages in the formation of one droplet system, and representing a continuous time of 3·3 sec.$^{-3}$. Initially it was attempted to obtain pictures using the stroboscopic illumination only, but the long exposures made necessary by the low-power neon lamp did not give perfectly clear results. (A 10-sec. exposure means the superimposition of 1,000 droplets.) The final series of photographs, of which the accompanying illustration is one, was obtained using a 56-Joule, 1-microsecond flash tube. The triggering of this tube, to coincide with desired stage



of droplet formation, as seen through a low-power telescope and illuminated by the strobo-torch, was achieved by synchronizing the trigger pulse with the grid signal to the strobo-torch, with a manual firing switch. The illustration shows the primary drop, free and oscillating as it moves away from the capillary, with an unstable filament of water detached from the reed and about to divide into a secondary droplet and afterwards a number of subsidiary droplets.

To enable the diameters of the droplets to be measured, they were caught in shallow fabricated dishes containing castor oil[1] or, for the smaller sizes, a mixture of paraffin oil and hydraulic fluid. If they successfully penetrate and hang from the surface of the oil, their shape remains spherical, and they do not evaporate for an appreciable time.

As one example of the use to which the apparatus could be put in the study of single droplet combustion, it was found possible, using kerosene in place of water and with the axis of the capillary horizontal, to ignite a stream of drops ascending nearly vertically. Burning continued at the top of the trajectory over a distance of 1·5 in. and was maintained by the arrival of fresh droplets.

I believe that the uniformity of size in a single stream of drops from the apparatus outlined here is much greater than that obtained with a spinning-disk type sprayer, although it has the disadvantage of producing only a limited quantity.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this letter. I also wish to record my thanks to A. J. Colbourn for his assistance in obtaining the photographic records.

N. A. Dimmock
National Gas Turbine Establishment,
Farnborough,
Hants.
June 20.

[1] *Engineering*, **159** (Jan. 26, 1945).

Adsorption of Insoluble Vapours on a Water Surface

Dr. C. L. Cutting and one of us have completed an extensive series of measurements on this subject, and a paper embodying them is now pending publication. Reference is there made to earlier work, especially that of Cassel and Formstecher[1]. The Gibbs's equation is used in the form $\Gamma_2^{(1)} = \frac{p}{RT}\frac{\partial F}{\partial p}$, and the methods of Ferguson and Hakes[2] and of Sugden's[3] adaptation of the maximum pressure in bubbles method have been used to determine the F—p curves, which have been followed up to a value of partial pressure close to saturation. They have proved very suitable methods for a wide survey of the field.

We have now, however, applied successfully the vertical film balance to this problem, which has enabled accurate measurements to be made on a static surface, the contact angle being zero. The vertical film balance is incorporated into the apparatus shown in Fig. 1. The water is contained in a trough A, which enables a clean surface to be formed by overflowing from B (*vide* Harkins and Jordan[3]). The plate D hangs in the trough, being suspended through a tube in the stopper E from an analytical balance fitted with a mirror on the beam, so that deflexions can be measured by means of a lamp and scale. Initially, the plate is hung in the clean surface and the balance adjusted to equilibrium. The vapour of the adsorbate is passed at varying partial pressures over the surface through four nozzles, G, by carriage in a stream of air. As the surface tension decreases the plate rises, and the surface pressure, F, can be calculated directly from the observed deflexions.

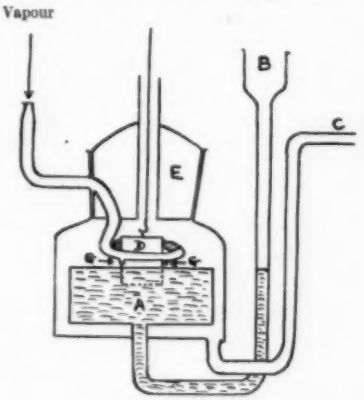


Fig. 1

The reductions of tension are almost linear at low partial pressures in all cases, but increase progressively up to the saturation value. As an illustration, in Fig. 2 the calculated $\Gamma_2^{(1)}$ is plotted against the vapour pressure for the case of *n*-hexane on water at 0° C., 7·5° C. and 15° C., and a clear picture is given of the rapidly increasing adsorption as the neighbourhood of saturation is approached. The values of the adsorption at saturation may depend greatly on changes in surface tension, perhaps very small, occurring at partial pressures of vapour extremely close to saturation, and until we have examined this point more critically experimentally, we are uncertain that the values indicated in the graphs represent accurately the adsorption at, or very close to, saturation.

If one assumes that the hydrocarbon molecule is lying flat and exposing its maximum surface to the water interface, then a monolayer value is approached at approximately 92 per cent of saturation; but above this value of partial pressure, the extent of adsorption rapidly increases to values of two to three times the monolayer value. Much smaller values would be obtained, approaching a monolayer only, if it were assumed that, as saturation is approached, the molecules become oriented vertically, exposing an

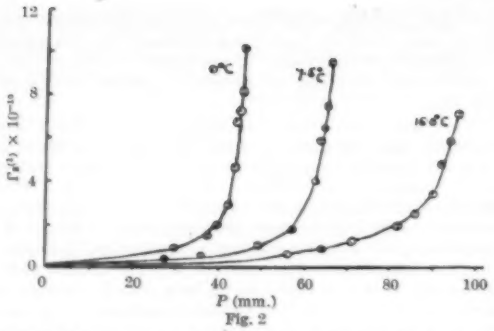


Fig. 2

area to the surface of about 20 sq. A. It will be noted that the isotherms are convex to the pressure axis as is the case for the curves shown by Cassel and Formstecher, and for the adsorptions of all the insoluble vapours on a water surface investigated by Dr. Cutting. This is the rarely observed type III curve of Brunauer[4], and it is of interest that preliminary calculations show that the heats of adsorption are less than the heats of liquefaction, in agreement with Brunauer's views, which are similar to those of Langmuir[5], in whose paper the occurrence of multilayers receives quantitative consideration in Case VI. However, the above form of the adsorption isotherm is not observed only in the case of multilayer formation, when certain relationships exist between the lives of the adsorbed molecules at the surface and in the subsequent layers, but would, as Cassel and Formstecher showed, be obtained also when the adsorption is less than a monolayer if the film were gaseous with the attractive correction preponderating.

One of us (R. H. O.) is a holder of a maintenance allowance from the Department of Scientific and Industrial Research, and a Royal Society grant has partly defrayed the cost of the investigation.

R. H. Ottewill
D. C. Jones

Queen Mary College,
University,
London, E.1.
May 7.

[1] Cassel and Formstecher, *Kolloid Z.*, **61**, 18 (1932).
[2] Ferguson and Hakes, *Proc. Phys. Soc.*, **41**, 414 (1929). Sugden, *J. Chem. Soc.*, 27 (1924).
[3] Harkins and Jordan, *J. Amer. Chem. Soc.*, **52**, 1751 (1930).
[4] Brunauer, "The Adsorption of Gases and Vapours", 150 (1945).
[5] Langmuir, *J. Amer. Chem. Soc.*, 1372 (1918).

Positive Point-to-Plane Spark Breakdown of Compressed Gases

The increase of spark breakdown potential of gases with increase of pressure does not apply for all electrode configurations. It has been shown[1–4] that an anomalous decrease occurs in the positive point-to-plane breakdown potential of some gases at several atmospheres pressure.

An investigation of this effect using air, nitrogen (oxygen-free), 'Freon 12' and sulphur hexafluoride is being made in this Department. Examples of spark breakdown voltage–pressure curves obtained for these gases are shown in the accompanying graph, together with details of the gap configuration. It seems from these results that two conditions are necessary for the existence of this phenomenon: (1) that a divergent field configuration, with the high-field region at the anode, be used, and (2) that spark-over occurs in a gas which forms negative ions. In the case of positive point-to-plane spark-over in a gas mixture, only one electron-attaching gas is necessary; for example, compressed air[2,3] and commercial nitrogen[1] exhibit this effect, whereas nitrogen (oxygen-free) does not.

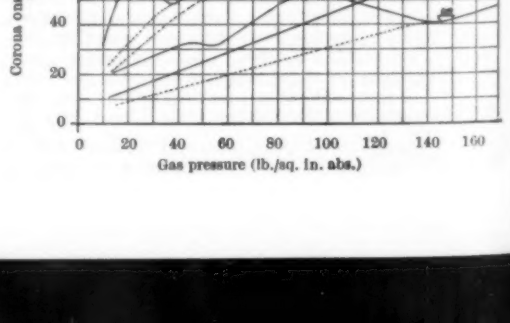
At pressures between the critical pressure, P_c (where the corona onset curve coincides with the spark breakdown curve), and the pressure corresponding to the maximum breakdown voltage, P_m, the sparking paths are curved. Howell[3] has reported on this, and photographs of curved sparks, taken from two mutually perpendicular directions, have been obtained here. In electron-attaching gases at pressures below the critical pressure, a visible, fan-shaped corona at the anode precedes spark-over. At pressures higher than P_c, sparking occurs without corona; no corona has been observed here in nitrogen (oxygen-free) at pressures higher than 30 lb. per sq. in. abs.

These phenomena may be tentatively explained by considering the effect of pressure increase on the mechanisms of positive streamer formation.

The lateral spreading of electrons at the tip of a Townsend avalanche probably decreases with increase of pressure. This causes increased field distortion by positive space-charge and, therefore, facilitates the production of photons by electron-positive ionic recombination[4]. Increase of pressure also increases the absorption coefficients for these photons. The chance of a streamer developing across the low-field regions of a point-to-plane gap is therefore increased.

These considerations seem to explain the observed effects in nitrogen, where initial streamers caused breakdown. Such self-sustaining streamers could also cause spark-over in electron-attaching gases at pressures higher than P_c.

In electron-attaching gases at pressures lower than P_c, other mechanisms occur which reduce the field distortion of a primary avalanche and make it less likely for a streamer to cross the gap. Most important of these streamer-quenching mechanisms is probably the attachment of avalanche electrons, especially those at the rear of the advancing tip, forming relatively immobile negative ions. This reduces the ionization and the yield of photons in an initial avalanche. In certain gases, for example, CCl_2F_2, dissociation processes cause molecules with high electron affinities to be introduced in the avalanche path[5].



In electron-attaching gases at pressures lower than P_e, quenched streamers spread photo-electrically over the point to form a self-sustaining corona. This corona effectively extends the point and makes the applied field less divergent.

The positive ions created in the corona constitute a mid-gap space-charge which further distorts the field. At pressures below P_m, it is assumed that this space charge does not reduce the field at the face of the corona sufficiently to prevent axial breakdown streamers. At P_m reduced diffusion of positive ions is assumed to increase space-charge distortion so much that breakdown streamers are forced to take curved paths.

Since the curved sparks follow fairly low-field paths, the condition of axial breakdown is being approached. Increase of pressure beyond P_m, therefore, enables curved streamers to develop with less field distortion. The spark breakdown-voltage and corona current at spark-over would be expected to decrease at pressures above P_m [2]. This decrease of spark breakdown-voltage and breakdown corona-current will continue until pre-onset streamers initiate axial breakdown of the gap with field distortion due to corona space charge at zero.

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Energy in Electrostatics

Difficulties encountered by Stoner[1,2] and Guggenheim[3-5] in their attempts to apply thermodynamics to systems which contain magnetizable matter have made these writers aware of important defects in the usual development of the notion of energy in the theory of magnetism and in the analogous theory of electrostatics. The difficulties occur at the outset, when it is desired to write a general equation to express the first law of thermodynamics; such an equation must allow for density change in the material substance of the system and must include a term to allow for variation of magnetic energy. It is then essential to express this latter variation in a form which is valid when the material bodies in the system are deformable. Stoner and Guggenheim have not done this, and, besides, their discussion excludes systems in which hysteresis can occur. In the remarks which follow I refer to the analogous electrostatic problem.

The objection insisted upon by Guggenheim to the available accounts of electrostatics is that the theory is constructed with the particular relation $\mathbf{D} = K\mathbf{E}$ especially in mind, and that in consequence these accounts fail to establish notions and formulæ of general validity. In the case of energy and the formulæ pertaining thereto, there is serious confusion and error. With this criticism I am in complete agreement; I believe that no thoroughly satisfactory account of the energy in electrostatic systems has been presented anywhere. The peculiar difficulties of a general theory appear to have been recognized by De Donder[6], who writes: "Quand on étudie *l'énergie électrique localisée* dans un champ électrique dû à des volumes polarisés, il se présente une réelle difficulté; nous la surmontons en nous plaçant respectivement au point de vue *microscopique* et au point de vue *macroscopique*".

Guggenheim has re-examined the notion of energy in electrostatics and derives a work formula which he claims to be of general application. Thus he writes concerning an electrostatic system which contains dielectrics, "for an infinitesimal change in the system either of an electric charge, or a conductor, or a dielectric, the electric work done on the system is given by

$$w = \int dV\ \mathbf{E}\ d\mathbf{D}". \qquad (1)$$

This is a mistake.

A crucial point[7] which has not been noted explicitly before is that the general electrostatic system containing dielectrics is *not mechanically conservative*. That is to say, there is no function depending only upon the position of the charges and the configuration of the dielectric bodies in the system whose decrement for a displacement of the system is equal to the work done by the mechanical forces in the system. It is only by a detailed and formal development of the theory of dielectrics *ab initio* that this assertion can be fully substantiated. I remark simply but emphatically that there is profound confusion in the literature between the notion of energy as a physical entity and the notion of energy as a mechanical potential energy function.

Consider a common statement that the electrostatic energy of a system is

$$\tfrac{1}{2}\int \mathbf{E}.\mathbf{D}\ dv. \qquad (2)$$

This is meant to imply that the function (2) is a mechanical potential energy function for the system. It will be so, subject to two essential provisos: first, that the vectors $\mathbf{E}$ and $\mathbf{D}$ should be linearly related; and secondly, that the dielectric bodies in the system should be undeformed. Guggenheim insists upon the necessity of the first condition, and so his work formula (1) has been derived to apply when $\mathbf{E}$ and $\mathbf{D}$ are not linearly related. However, he has failed to recognize the second condition, and consequently (1) is invalid unless this restriction is stated. Guggenheim's statement quoted above is thus false specifically because it permits a movement or deformation of the dielectric bodies present in the system.

It is easy to modify (1) so as to make it apply generally. Consider an electrostatic system which consists of a distribution of charge with density ρ in a volume v_1 and a dielectric body occupying a volume v_2. If δW is the work done by the mechanical forces in the system during an infinitesimal movement of the system, write (1) in the form

$$\delta W = -\int \mathbf{E}.\delta\mathbf{D}\ dv = -\int \mathbf{E}.\delta\mathbf{E}\ dv - \int \mathbf{E}.\delta\mathbf{P}\ dv,$$

where $\mathbf{P}$ is the polarization. This formula holds, provided the dielectrics in the system are undeformed. However, if the relation is rewritten as

$$\delta W = -\int \mathbf{E}.\delta\mathbf{E}\ dv - \int \mathbf{E}.\delta(\mathbf{P}\ dv), \qquad (3)$$

it is true generally.

I have discussed elsewhere[7] the method of Helmholtz for deriving the mechanical force acting in a dielectric. This method involves deforming the dielectric and calculating the work done by the

mechanical forces acting in the system from the energy function (2) when **E** and **D** are linearly related or by use of the formula (1) in the general case. Strange and elaborate expressions for the force acting on the dielectric are obtained[8]. Larmor and Livens reject the Helmholtz method and the results obtained by its means, and propose instead an elementary formula for the force acting on the dielectric derived directly from the notion of a polarized medium. I have shown that the deformation method leads to the formula of Larmor and Livens provided the work done in the deformation is calculated from (3) instead of from (1) or (2).

Finally, I have shown[7] for the case of a fluid dielectric how to derive the equation sought by Stoner and Guggenheim to express the first law of thermodynamics. The method has since been extended to obtain the corresponding equation for solids.

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June 19.

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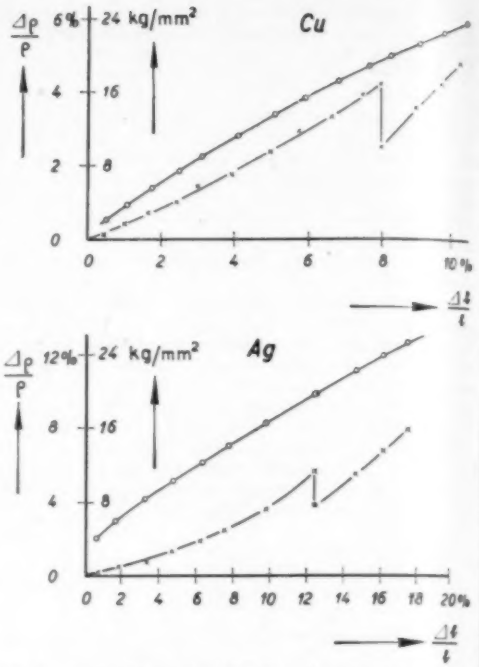
Change of Resistivity by Cold Working at Liquid-Air Temperature

THE relative change of resistivity ($\Delta\rho/\rho$) with plastic deformation at liquid-air temperature has been measured on several materials. Wires of copper, silver and aluminium which had been soft-annealed were stretched. The tension producing the extension as well as the resistivity were measured. The tension was removed after extension, and the resistivity was measured when there was no stress on the wire. The tension was then applied and increased so as to produce further plastic deformation. At an extension of approximately 10 per cent, the wire was removed from the liquid air and allowed to warm up to room temperature or heated to a higher temperature. The wire was then again placed in liquid air and the resistivity measured. The tension required to produce further plastic deformation was then determined as well as the resulting change of resistivity $\Delta\rho/\rho$.

It can be seen from the accompanying graphs that there is a discontinuity in the $\Delta\rho/\rho$ versus $\Delta l/l$ curve at the point where the temperature of the specimen was increased for a short while. There is no corresponding discontinuity in the tension versus $\Delta l/l$ curve. The minimum time for which the specimen was kept at room temperature was 10 min. No further decrease in $\Delta\rho/\rho$ was observed if the specimen was kept at room temperature for longer periods (up to 18 hr.).

For aluminium the relative decrease in $\Delta\rho/\rho$ was considerably larger than for copper or silver. The effect of keeping the specimen at higher temperatures up to 150° C. was investigated for copper and silver. No further decrease in $\Delta\rho/\rho$ was observed.

As the curves of tension versus $\Delta l/l$ are continuous, whereas there are discontinuities in the $\Delta\rho/\rho$ versus $\Delta l/l$ curves, the experiments show that the mechanism producing hardening by cold work is at least in part different from that producing the change of resistivity. This might explain the discrepancy between the observed values of $\Delta\rho/\rho$ and those calculated from the work done in producing dislocations[1].



Above: Copper drawn at −183° C. to 8 per cent extension, allowed to warm up to 20° C. and kept there for 3 hr., then drawn further at −183° C. to an extension of 11 per cent
Below: Silver drawn at −183° C. to 12 per cent extension, heated to 140° C. and kept there for 10 min., then drawn further at −183° C. to an extension of 17 per cent
x—x, $\Delta\rho/\rho$ versus $\Delta l/l$; o—o, tension versus $\Delta l/l$.

The magnitude of $\Delta\rho/\rho$ depends to a very great extent on the annealing temperature, slightly different heat treatments changing $\Delta\rho/\rho$ by a factor of 2. The previous history of the specimen may also be important. The discontinuity in the $\Delta\rho/\rho$ versus $\Delta l/l$ curve, however, always occurred.

The investigation is being continued. These measurements were made under the direction of Prof. M. J. Druyvesteyn (Delft), to whom we express our thanks. One of us (W. H. A.) also wishes to thank the South African Council of Scientific and Industrial Research for a research grant which made it possible for him to attend the Technische Hogeschool, Delft.

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Johannesburg. June 19.

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Absorption Spectrum of Tin Vapour in the Schumann Region

As part of a programme of studies of absorption spectra of vapours of metallic elements in the far ultra-violet[1], exploratory observations have now been made for tin, with the results here described.

The Sn I emission spectrum has been subjected to careful study by Meggers[2], who made new observations from λ1,697 to the end of the photographic infra-red, and also embodied bolometer measurements

made by other observers in the photographically inaccessible region. All terms and transitions classified by him belong to the series spectrum, involving excitation of one of the $5p$ electrons from the $5s^2\ 5p^2$ ground-configuration, though he surmises that a pair of superfluous levels found may be part of the $5s\ 5p^3$ configuration. Some of the terms of the latter are likely to lie above the first ionization potential of tin (7·3 volts), and it is expected that combinations with these will show up better in absorption.

With an arrangement similar to that used in the cases of indium and gallium[1], the absorption spectrum of tin vapour has been photographed in the range 1,100–2,300 A.

At a furnace temperature of 1,600° C., many absorption lines were obtained, all, or nearly all, of which are believed to belong to tin and not to impurities. Of twenty-one lines in the 1,600–1,800 A. range, seventeen are new. The remaining four, namely, λλ 1,793·4, 1,753·3, 1,729·2, 1,714·1, were observed in emission by Meggers, but are unclassified; these four lines are thus shown to be combinations with the ground-term 5^3P. Many of the lines of this group are diffuse, and a few of considerable breadth (10–20 A.). In the range 1,300–1,400 A. there occurs a strong triplet exhibiting the intervals of the ground-term.

At 1,800° C. the broader lines in the 1,600–1,800 A. range become so wide as to obliterate intervening structure. At this temperature also, all the stronger combinations with the ground-term listed by Meggers above 1,800 A. are present in absorption.

For these initial exposures, fast coarse-grained plates were used, and the complication of impressing good wave-length standards was avoided. In order to make as complete an analysis as possible, improvements in these respects are in hand. For the present, occurrence of the ground-term intervals in the rather rough measurements possible enables the placing of three new levels, each having $J = 1$, at the following positions with respect to Sn II $5s^2\ 5p\ ^2P_{1/2}{}^\circ$:

Level	cm.$^{-1}$ above Sn II $5^1P_{1/2}{}^\circ$
A	16,797 ± 10
B	2,611 ± 5
C	1,246 ± 5

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'Sudden Commencements' in Geomagnetism

'Sudden commencements' which appear in magnetogram traces have been recognized in the past more or less by their similarity to accepted typical movements, and the 'normal' s.c. has been subdivided into two types according as the main movement is preceded by a smaller movement in the opposite direction or not. In the paper on 'sudden commencements' by H. W. Newton[1] in 1948, the second type was regarded as one showing the preliminary movement in all three traces, though in the later analysis it was shown that the initial movement or 'tail' might take place in one element only, such as *H* or *D*. The frequency in which the tail movement was observable in *D* and not in *H* was slightly greater than *vice versa*.

A recent note by Ferraro and Parkinson[2] has suggested that the frequency of occurrence of type II

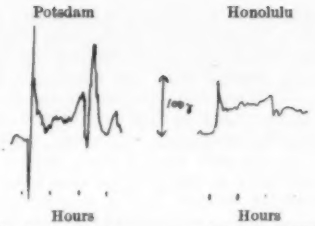

Fig. 1. Sudden commencement, May 13, 1921

s.c.'s may be a function of geomagnetic longitude, being a minimum at the longitude of Honolulu and a maximum at that of Greenwich or Abinger. In the note the types of s.c. are defined only in relation to the horizontal force *H*. This is, of course, possible, since the definition is to some extent arbitrary, but it leaves out the cases in which the preliminary movement is apparent in *D*, though not in *H*. With this definition, the ratio of type II s.c.'s to all s.c.'s for Greenwich as derived from Newton's paper would read 0·42 instead of 0·55. It would still leave the Greenwich point high on the graph, however.

As a rough test of the validity of the graph, the corresponding frequency of s.c.'s showing the preliminary movement in *H* only was computed for Sitka (geomagnetic longitude 275°). Published copies of the magnetograms for that station were available for the three years 1946–48 by courtesy of the U.S. Department of Commerce, Coast and Geodetic Survey. The result showed a frequency of type II s.c.'s comparable with Abinger, though the longitude would indicate from the graph a minimum similar to Honolulu. Too great weight cannot be placed on this result, obtained from only three years magnetograms, and Sitka may be an anomalous station. Some further evidence, though again for a very short period of time, was available from the *Journal of Geophysical Research*, s.c.'s for 1949 being classified as above. Hermanus, longitude 80°, showed a very small proportion of type II s.c.'s, while College, Apia and Amberley, with longitudes all near that of Honolulu, gave high proportions, of the same order as Abinger.

A feature which would be expected from low-latitude stations like Honolulu and Tucson is the marked reduction in the amplitude of oscillations observed in the trace during storminess. This is illustrated by the traces at Potsdam and Honolulu during the first few hours of the great storm of May 13, 1921 (Fig. 1), which show also the very gradual build-up of the s.c.

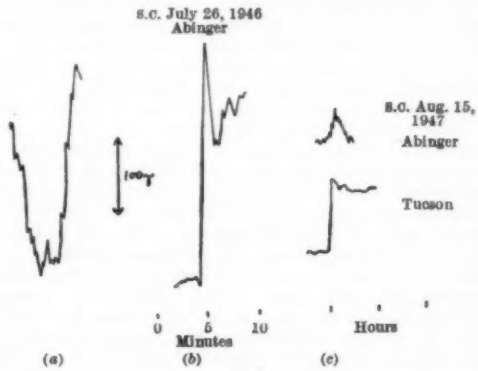

Fig. 2

at Honolulu. One possibility is that the 'tail' effect in s.c.'s may be connected with such oscillations, as movements found during storm periods bear strong resemblance, superficially at least, to s.c. types (Fig. 2*a*). At times, too, the s.c. cannot be separated from the subsequent oscillations of the storm (Fig. 2*b*), merging imperceptibly into them, while at others a normal s.c. at one station may appear as a succession of strokes or oscillations at another (Fig. 2*c*). If the serrated nature of the magnetogram traces during storms is due to superimposed oscillations, the presence of the 'tail' may also be explained in this way. One would then expect dependence on geomagnetic latitude in their occurrence, as the oscillations increase with latitude, but the evidence from stations like Apia and Hermanus would scarcely support this. A possibility is that the absence of the preliminary movement at some stations may be due to damping caused by induced ionospheric currents; the differing rates of change with time of the main stroke when s.c.'s at several stations are compared would suggest such damping. But evidence from a number of widespread stations would be necessary to establish such effects.

This note is communicated by courtesy of the Astronomer Royal.

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Role of the Thyroid in Sexual Development in the Male

Considerable work has been done in the field of thyroid physiology; but the role of the thyroid in male fertility needs further clarification, since extremely variable results have been observed, due, it is believed, to species and breed differences, age and stage of sexual development, dose and duration of the hormone administration, plane of nutrition and environmental temperature. With the previous work in view, an attempt has been made to study the effects of known levels of thyroid stimulation and inhibition, under natural environmental conditions, upon the gonads, that is, on spermatogenesis, the development and secretory activity of the interstitial cells, accessory male organs, sex behaviour and semen evaluation of the growing male rabbit and the ram at various stages of sexual development.

In a series of experiments, it was observed that mild hyperthyroidism within the physiological range stimulated spermatogenesis and increased the secretory activities of the interstitial cells of the testis as judged by the growth and functional activities of the accessory male organs and the sex behaviour in growing male mice[1], buck rabbits and rams. On the other hand, thyroidectomy or prolonged thiouracil-treatment interfered with the normal process of spermatogenesis; the seminiferous tubules showed atrophic and degenerative changes, the spermatogonial cells being disorganised and the tubules appearing to contain an abnormal accumulation of cells. The Leydig cells showed greater abnormal appearances, and the normal interstitial spaces showed an increase in the fibrous tissue but with reduced cellular elements. Mild hyperthyroidism resulted in precocious sexual development in the young male rabbit and the ram, while prolonged hypothyroidism or severe hyperthyroidism interfered with the normal reproductive processes.

Thyroxine-treatment at the above levels greatly improved the sexual libido and sex drive in the buck rabbit, ram and boar, which previously had shown lessened sexual libido and poor sex drive. Thyroidal stimulation during the non-breeding season prevented to a great extent the seasonal variations in sexual desire and quality of semen in the young ram. There was a considerable improvement in the semen of the treated buck and the ram. Continued administration of larger doses of thiouracil to the growing male markedly impaired the sex behaviour and the semen was of very poor quality. The degree of impairment of these functions depended upon the age of the treated male, dose and duration of treatment and the environmental conditions.

The mechanism whereby the thyroid influences gonadal functions probably involves a complex series of interactions. The depression of sexual development during hypothyroidism may be due, in part, to reduced secretion of the pituitary gonadotrophins, while the increased functional activities of the testes and accessory male organs of young mice[1], the buck and the ram, observed in mild hyperthyroidism, is probably due to the increased output of hypophyseal gonadotrophic hormones which in the presence of thyroxine are responsible for the growth of the male sex organs. The follicular stimulating hormone stimulates the growth of the seminiferous tubules, and the increased production of luteinizing hormone stimulates the secretion of the male sex hormone by the Leydig cells of the testes. The increased output of the male sex hormone in turn is responsible for the growth and functional activities of the accessory male organs and sexual behaviour. Further, the thyroid hormone may also facilitate the utilization of hypophyseal gonadotrophic and gonadal hormones by the organism due to its metabolic conditioning of the cells involved.

I am indebted to Dr. J. Hammond and Dr. A. Walton for their help and to Mr. A. G. Carruthers for statistical analyses of the results.

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Effect of Acetoacetic Acid on Reduced Glutathione Content of Blood in Rabbits

Nath and Brahmachari[1] have shown the hyperglycæmic effect of injections of sodium acetoacetate in rabbits. Lazarow[2] has attempted to correlate the diabetogenic action of some chemical compounds with their ability to lower the reduced glutathione content of the blood. With the view of finding whether acetoacetic acid influences the reduced glutathione content of blood, some experiments were conducted on rabbits. The number of animals used was ten.

It was found that the repeated injection of small doses gradually increasing from 25 to 75 mgm./kgm. of body-weight of sodium acetoacetate to rabbits lowered the reduced glutathione content of their blood on an average by 40–50 per cent in twenty days.

The effect of single massive subcutaneous injection of sodium acetoacetate was also studied. The doses employed were 100, 200 and 300 mgm./kgm. of body-

weight. Two animals were used for each dose. It was found that, depending on the dose, the reduced glutathione content of the blood was reduced by 30–66 per cent. A second subsequent massive injection to the same animals on the next day resulted in lowering the reduced glutathione content still further.

Gregory and others[3] have found that the injection of anterior pituitary preparations lowers the glutathione content of tissues. Recently, Conn[4] has shown that there is a direct correlation between the production of a transitory diabetes in man produced by injecting a purified adrenocorticotrophic hormone, and the blood-glutathione level. Leech and Bailey[5] have investigated the effect of alloxan, and they found that the blood-glutathione content may fall to near zero values on alloxan injection. In view of these findings and the results reported here, it may be suggested that the lowering of reduced glutathione content of the blood is in some way responsible for the onset of diabetic troubles and *vice versa*; thus substances causing such reduction of reduced glutathione may increase susceptibility to the development of diabetes.

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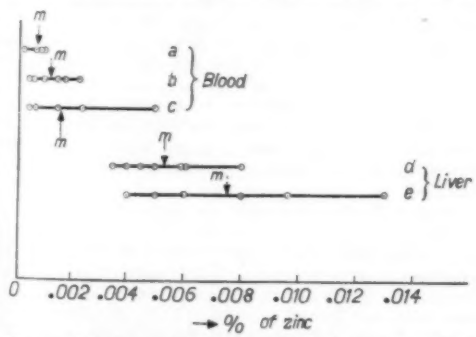
A Possible Correlation Between the Zinc Content of Liver and Blood and the Cancer Problem

In biochemical literature various metals are considered to be related to proteins present in the human body. These metals can be regarded as 'tracers' for these proteins. It was thought worth while to try to estimate these proteins by analysing ash of tissues and body liquids by means of the spectrograph for these metals. The direct-current carbon arc gives satisfactory results.

Among the elements iron, aluminium, calcium, sodium, potassium, magnesium, phosphorus, copper, zinc, lead, manganese, chromium, molybdenum, silver and silicon, determined during preliminary experiments, it was found that in the case of malignant growth the range of the zinc content was extended. Although differences of mean values found are not particularly significant (see table and graph), it seems of vital importance to investigate on one hand the behaviour of zinc-containing proteins in the human body, and on the other hand the relation between zinc and malignant growth.



Ranges of zinc concentration found in blood and liver of: *a*, people with no disease (blood); *b*, patients with non-tumorous disease (blood); *c*, patients with malignant growth (blood); *d*, patients with non-tumorous disease (liver); *e*, patients with neoplasms (liver); *m*, mean values for zinc found.

Mean values and standard deviations of zinc concentrations found in various samples of blood and liver

Series		n†	Mean per cent	Stand. dev.	Stand. dev. of mean
Blood	*a* (no disease)*	6	0·0007	0·00026	0·0001
	b (non-tumorous disease)	7	0·0012	0·00062	0·0002
	c (malignant growth)	7	0·0016	0·0015	0·0006
Liver	*d* (non-tumorous disease)	7	0·0053	0·0014	0·0005
	e (patients with neoplasms)	6	0·0075	0·0030	0·0012

* Cf. Vallee's value‡ found by using an improved dithizone method; mean: 0·00083 per cent; stand. dev. of mean: 0·00020 per cent (Vallee, B. L., and Gibson, J. G., *J. Biol. Chem.*, **176**, 445; 1948).
† n = number of measurements.

Various samples of material have been obtained from Dr. P. Nieuwenhuyse, professor of pathology in the University of Utrecht, who controlled all tissues, blood, etc., by histological and anatomical investigation.

Results will be published in full in *Rec. Trav. Chim. Pays-Bas.*

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June 20.

Dextrorotatory Acids of Tubercle Bacilli Lipids

We wish to report that the dextrorotatory acids of the lipids of human tubercle bacilli, hitherto believed to be saturated acids, are αβ-unsaturated acids.

In a previous communication[1], one of us has described the isolation of three dextrorotatory acids. This was effected by the fractional crystallization of semicarbazones and 2 : 4-dinitrophenylsemicarbazones of the acetol esters derived from the parent acids. Two of these acids (C_{18} and C_{20}) were solids and one (C_{16}) was a liquid. It has now been found that the solid acids are readily separable from other constituents of the mixture, owing to the sparing solubility of their potassium salts in cold ether. The analyses already given[1] included somewhat low figures for hydrogen (calculated for the saturated acids), and the theory for the new formulæ with two hydrogens less is in better agreement with the results.

The experimental evidence for the αβ-unsaturation of these acids may be summarized as follows:

The solid acids[1] ($C_{18}H_{34}O_2$, $[\alpha]_D^{20°}$ + 11·7° and $C_{20}H_{38}O_2$, $[\alpha]_D^{20°}$ + 4·8°) (all rotatory powers were taken in ether; c, 10–15) exhibited in purified cyclohexane λ_{max} 220 mμ (log ε_{max} 3·9) and λ_{max} 219 mμ (log ε_{max} 3·9), respectively; the liquid acid[1] ($[\alpha]_D^{20°}$ + 11·1°) gave λ_{max} 220 mμ (log ε_{max} 3·9).

A mixture of the solid acids (from the sparingly soluble potassium salts; found: C, 78·8; H, 12·5; $C_{18}H_{34}O_2$ requires C, 79·6; H, 12·8 per cent. $C_{20}H_{38}O_2$ requires C, 80·0; H, 12·9 per cent) exhibit-

ing $[\alpha]_D^{20°} + 7·9°$, $n_D^{36°}$ 1·4600, λ_{max} 220 mμ (log ε_{max} 3·9) gave, on hydrogenation in acetic acid in the presence of platinic oxide at 2 atmospheres pressure, a solid with $[\alpha]_D^{20°} + 1·1°$, $n_D^{36°}$ 1·4516 (found: C, 78·9; H, 13·3; $C_{22}H_{44}O_2$ requires C, 79·2; H, 13·2 per cent. $C_{30}H_{60}O_2$ requires C, 79·7; H, 13·3 per cent). The liquid acid (from the easily soluble potassium salts), having $[\alpha]_D^{18°} + 10·3°$, $n_D^{36°}$ 1·4655, λ_{max} 220 mμ (log ε_{max} 4·0) (found: C, 79·2; H, 12·8; $C_{26}H_{50}O_2$ requires C, 79·2; H, 12·7 per cent), on hydrogenation yielded an oil, $[\alpha]_D^{18°} + 1·7°$, $n_D^{36°}$ 1·4563 (found: C, 79·2; H, 13·2; $C_{26}H_{52}O_2$ requires C, 78·8; H, 13·1 per cent). The marked decrease in rotation observed on hydrogenation of the unsaturated acids indicates that a centre of asymmetry resides near to the double bond.

All the foregoing hydrogenated acids exhibited no measurable absorption in the ultra-violet.

Examination of the infra-red spectra of the solid and liquid acids indicated the presence of a double bond in conjugation with the carboxyl group, whereas the hydrogenated products showed the absence of unsaturation.

The mixture of the hydrogenated solid acids was subjected to a stepwise degradation. It was converted to the α-bromo-acid and thence to the α-hydroxy-acid; the latter on oxidation with lead tetra-acetate afforded a ketone which formed a semicarbazone, m.p. 64–65°, after recrystallization from alcohol (found: N, 8·2; $C_{30}H_{61}ON_3$ requires N, 8·8 per cent). The formation of this ketone indicates the presence of a substituent in the α-position to the carboxyl group in at least one of the constituents of the mixture.

Ozonization of the solid acids yielded as the main product an acid, $[\alpha]_D^{20°} + 2·4°$, $n_D^{38°}$ 1·4528, of molecular weight comparable with the starting point. Oxidation with potassium permanganate in acetone appears to yield the same acid. Examination of the ultra-violet and infra-red spectra showed the absence of unsaturation and of carbonyl groups. It was significant that acetic acid (about 70 per cent yield) but no oxalic acid was found among the ozonization products.

Full experimental details will be published later and the investigation is being actively pursued; in some aspects in collaboration with Sir Robert Robinson.

Anderson and associates[2] have isolated 'phthioic acid' ($[\alpha]_D + 12·56°$) from human tubercle bacilli lipids. Their procedure involved hydrogenation of the crude mixture of acids, and they erroneously assumed from the iodine values of the original mixtures that 'phthioic acid' is saturated prior to hydrogenation. The acids isolated by us showed practically zero iodine value, but this involves no anomaly since αβ-unsaturated acids are known to be unreactive to halogens or equivalent reagents. The rotatory powers of all three dextrorotatory acids are markedly decreased on hydrogenation, and hence we conclude that the hydrogenation carried out by Anderson and Spielman[2] was incomplete. It is highly improbable that 'phthioic acid' is homogeneous, and the evidence (especially from C-methyl determinations) accords best with the view that it was substantially derived from the C_{26} acid (above) by partial hydrogenation.

We are indebted to Glaxo Laboratories, Ltd., for the provision of extracts of tubercle bacilli, to Dr. F. B. Strauss for the ultra-violet spectra, and to Dr. L. N. Short for the infra-red spectra. The work of one of us (J. D. C.) has been facilitated by grants from the Rockefeller Foundation and the Dazian Foundation, New York.

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Fibrin Clots

Two kinds of fibrin have recently been distinguished by the test of whether or not they could be dissolved in 30 per cent urea[1,2]. Normal physiological plasma-clot is insoluble in urea, whereas the clot obtained by the action of purified thrombin on purified fibrinogen dissolves easily. It has further been established that both a thermolabile component of the serum and calcium ions are needed to form a urea-insoluble clot from the purified fibrinogen-thrombin system. The internal network structure of the two sorts of clot must be different in some way; and since urea-soluble fibrin can also be dispersed by certain solvents which are known to break hydrogen bonds, for example, guanidine and monochloracetic acid, it would appear that this type of network is held together by secondary forces only. In plasma-clot, however, the particle association seems to be reinforced by stronger linkages.

X-ray studies also reveal a difference between urea-soluble fibrin and plasma fibrin. Fibres of the latter stretch readily from the α- to the β-configuration (in fact, it is difficult to prepare well-oriented α-specimens without producing some β [3]), but greater extensions are required with urea-soluble fibrin[4]. The internal cohesion of plasma fibrin is therefore higher than that of urea-soluble fibrin, possibly by virtue of added cross-linkages. As judged by the X-ray test, urea-soluble fibrin has an internal cohesion intermediate between plasma fibrin and fibrinogen.

The viscosity of fibrin dissolved in urea is the same as that of the fibrinogen from which it was made, indicating particles of a similar kind in both. Incidentally, fibrinogen kept in 30 per cent urea solution does not become inactivated; after dialysis it can be recovered with its full clottability[5].

When the urea is removed from a fibrin solution by dialysis at about neutral *p*H, re-clotting takes place inside the dialysis bag. Solution, dialysis and re-clotting of the same specimen of fibrin can be repeated many times; and using large volumes of solvent for the repetition also ensures the elimination of the thrombin that was originally added. Thus the re-clotting effect can scarcely be ascribed to thrombin. Rather would it seem that the enzyme produces in fibrinogen a permanent change which thereafter always promotes clotting whenever the medium is suitable[6].

Plasma fibrin, insoluble in urea, dissolves in a mixture of 1 per cent thioglycollic acid and 30 per cent urea, and when the solvent is removed by dialysis the gel re-forms. While the action of urea alone is probably no more than intermolecular, it is uncertain whether the same can be said about the action of the mixture, and until more is known about the precise nature of the dispersed units it is not possible to infer where in the plasma-clot network the splitting by urea plus thioglycollic acid

occurs. Though it might be supposed that the effect of thioglycollic acid is due to its ability to reduce S–S bonds, it is very unlikely that plasma fibrin would differ from urea-soluble fibrin simply by possessing additional S–S linkages between the associated units; for it has to be borne in mind that neither fibrinogen nor urea-soluble fibrin has any free or masked sulphydryl groups available for possible S–S formation[5]. Moreover, urea-soluble fibrin cannot be converted into an insoluble kind by treating with oxidizing agents such as hydrogen peroxide. It is found, too, that plasma cannot be prevented from forming a urea-insoluble clot by adding chloroacetophenone or excess cysteine, so there is no indication, either, of any re-formation during clotting of the original fibrinogen S–S groups.

The serum factor, which with calcium ions is responsible for the urea-insolubility of the plasma-clot, retains its activity for weeks in plasma kept at 0° C.; but it is inactivated in a couple of days at room temperature. It is also destroyed if serum is heated at 60° C. for 10 min. The factor does not dialyse out from plasma; it seems to accompany fibrinogen in the plasma fraction precipitated on adding a half plasma-volume of saturated ammonium sulphate, but separation takes place on subsequent acid precipitation (*p*H 5·2–5·4) at 0° C. The serum factor is not identical with the anti-hæmophilic factor, since a hæmophilic blood-clot is like a normal one in being insoluble in urea.

As serum and calcium ions must be added in fairly high proportions in order to obtain a urea-insoluble clot by the action of purified thrombin, the possibility cannot be disregarded of a stoichiometric combination between serum factor and fibrin. If this idea is sound, it would suggest that the serum factor acts as a resistant cement between the fibrin units. The identification of the factor is still under investigation, and it might well turn out to be one of the few serum globulins already known to have a high tendency to occlusion within the clot[7].

My thanks are due to Prof. W. T. Astbury for his interest and encouragement, and to Dr. K. M. Rudall and Mr. W. R. Middlebrook for discussions. I am also indebted to Hoffmann–La Roche, Basle, for the gift of a thrombin preparation.

A more detailed account of this work will be published in due course elsewhere.

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Vermiculite–Organic Complexes

Montmorillonite is known to be capable of forming organic complexes of two kinds, one due to a cation-exchange reaction[1] and the other to the interlamellar adsorption of complete molecules[2,3]. Halloysite has also been reported as giving complexes of the latter type[2], and recently also vermiculite[4,5]. Using a typical vermiculite, complexes of both types have been obtained in this laboratory, and are being studied by means of X-ray diffraction.

The recent demonstration of the high exchange capacity of vermiculite for inorganic cations, together with its limited swelling properties[6,7,8], made it probable that substitution by organic cations could be effected, and this is found to be so. Complexes have been formed with codeine, *p*-phenylene-diamine, benzidine hydrochloride and brucine sulphate, the amount of displacement of the vermiculite basal reflexion depending on the concentration as well as the nature of the amine. It is noteworthy that the blue colour-change produced in benzidine by montmorillonite and other substances[9] is also produced by vermiculite.

The existence of the van der Waals type of adsorption in vermiculite was suspected when it was found that, during the weathering of biotite to vermiculite, a stage is observed at which a single layer of glycerol molecules can penetrate the structure with displacement of the basal reflexion from about 10 A. to 14 A.[10]. Further examination has shown that glycerol molecules do, in fact, enter the structure of true vermiculite and displace the interlamellar water, but that the effect is difficult to observe since the resulting spacing (d_{002} = 14·28 A.) is very close to that of the natural magnesium-saturated vermiculite (d_{002} = 14·36 A.). It can be observed easily in the case of vermiculite previously saturated with lithium or barium ions, both of which give a basal reflexion at about 12·2 A.[8], which is displaced to 14·28 A. on treatment with the glycerol. Small flakes of vermiculite treated with glycerol and rotated perpendicular to the *c*-axis show the line at 14·28 A. accompanied by a regular sequence of a dozen or more higher orders.

In the case of ammonium-vermiculite powder, addition of glycerol displaces the basal line to only a slight extent if at all[11], suggesting at most very limited penetration by the glycerol molecules. This also occurs with the other large monovalent cations tested, namely, potassium and caesium, which have similar basal spacings, and is probably due to the fact that when these ions enter the structure (which they do with difficulty) they are not associated with layers of water molecules as is the magnesium ion in natural magnesium-vermiculite. As a consequence of this, the alumino-silicate layers are able to approach each other more closely and can be re-separated only with difficulty.

The other organic molecules tested so far, namely, those of ethylene glycol, methanol, cyclohexanol, acetone and acetonitrile, show only limited penetration of the magnesium-vermiculite structure or none at all. If lithium-vermiculite is used, however, complex formation becomes easier in some cases.

It is clear that the adsorption mechanism of the glycerol molecule in vermiculite differs in certain respects from the corresponding process in montmorillonite. In glycerol–montmorillonite, the organic molecule orientates itself so that it is about 3·9 A. high, and double layers of molecules penetrate the structure[2]. In the case of glycerol–vermiculite, the interlamellar space available for the organic molecules is 5·0 A. high, and there is evidence that this is real spacing and not a mixed-layer effect. Hence, in glycerol–vermiculite, apart from the fact that only *single* layers of glycerol molecules are interleaved with the alumino-silicate layers, the organic molecules either (*a*) attach themselves to the clay mineral surfaces by a weaker binding force than exists in

glycerol–montmorillonite, or (*b*) orientate themselves differently with respect to the adjacent aluminosilicate surfaces. In vermiculite, moreover, the nature of the exchangeable cation present may influence indirectly the degree of complex formation.

An interesting additional point is the catalytic effect exerted by vermiculite on the decomposition of glycerol. If a small flake of vermiculite is boiled for a few minutes in glycerol, it acquires a black metallic coating (on the interlamellar surfaces as well as at the boundaries of the crystal). An X-ray photograph shows that the basal spacing has moved to 14·06 A. (with a regular series of higher orders). This would be consistent with the existence between the silicate lamellæ of *double* layers of carbon atoms arranged as in the graphite structure[12]. Fourier curves (along the *c*-axis) of this and of the normal glycerol–vermiculite structure are being prepared.

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A Symmetrodont Tooth from the Rhaeto-Lias

Since the discovery of the tooth *Morganucodon watsoni* in a fissure at the Duchy Quarry near Bridgend, Glamorgan, which yields a Rhaeto-Liassic mammalian fauna, about fifty teeth or fragments of teeth have been found.[1] With few exceptions the fauna consists of 'Triconodonts', identical with those collected by Prof. B. Peyer from Upper Rhaetic bone-bed material at Hallau near Schaffhausen. The only members of the fauna which are adequate for comparison with other material are the 'Triconodonts'. I wish to emphasize that all the known facts having a bearing on the geological age of the *Morganucodon* fissure are consistent with a Rhaeto-Liassic age.

On *Morganucodon* a few new points may be given. If one looks upon this lower post-canine as a 'prepantothere', the changes needed to lead to the pantotheres would be the following: the anterior accessory cusp which in *Morganucodon* is very small would have to disappear, and the antero-internal cingulum cusp would have to increase in size to make the paraconid. The highest cingulum cusp, well separated in *Morganucodon*, would also have to increase in order to form the metaconid. The very substantial posterior accessory cusp in *Morganucodon* would have to disappear and the talonid to become basined.

Dr. P. M. Butler has suggested to me that *Morganucodon* might be a 'predocodontid' and compared the specimen with *M*4 of *Peraiocynodon inexpectatus* from the Middle Purbeck of Swanage, Dorset. The disappearance of the rather large posterior accessory cusp of *Morganucodon* would make the two teeth agree in structure.

"Duchy 33", a symmetrodont tooth from the Rhaeto-Lias. *A*, internal view; *B*, crown view. Length of specimen 1·25 mm.

The posterior tooth preserved in *Microconodon tenuirostris* from the Rhaetic of North Carolina, shown presumably from the outer side, is surprisingly similar to the outer view of *Morganucodon*.

During recent work at the Duchy Quarry my wife found a fragment of matrix, and on inspecting it I detected a mammalian tooth. While the specimen was being prepared, a small part of the base of the main cusp was lost, and in consequence the true fitting of the main cusp is impossible; otherwise the specimen is complete and well preserved. The specimen can easily be described as a lower symmetrodont cheek tooth; in fact, there is not one character at variance with this identification.

The tooth is tricuspid, the central cusp being twice as high as the lateral ones. The three cusps include an angle of about 100°. They emerge from a common base which is indented on the inner side as well as on the outer side between the free apexes of the three cusps. The cingulum is smooth and surrounds the tooth completely. There is on the inner side of the crown no basin between the three cusps. Two well-separated roots are present. The enamel is smooth. The apexes of the two lateral cusps are worn away. The specimen has the laboratory number "Duchy 33".

It is therefore certain that I was incorrect in stating in my first paper on the *Morganucodon* fauna[1] that the Triconodonts in this fauna were the only representatives of mammalian life then in existence. There are at least two types of mammalian teeth present in the Rhaeto-Lias belonging to two of the four orders recognized as mammalian in the Upper Jurassic.

But in spite of the numerous tricuspid teeth from the Rhaeto-Lias which look mammalian, we still do

not know whether the animals to which the teeth belonged had a compound lower jaw or a simple one; in other words, whether the mammalian tooth development took place in a reptilian or in a mammalian jaw. The Tritylodontids show that the former was actually realized in the Ictidosauria.

Another question which now arises is whether we may expect even pantotherian teeth in the Rhaeto-Lias. At the moment we do not possess such a tooth and we are still at liberty to build sequences of 'grades' or phylogenies and similar schemes without being encumbered by it.

One may still assert that *Morganucodon* gave rise to the Pantotheria, and that the Symmetrodonta arose independently. One might assert that the co-existence of 'Triconodonts' (in order to make *Morganucodon* a triconodont one has anyhow to widen the diagnostic borders of the order Triconodonta) and Symmetrodonts in the Rhaeto-Lias is a logical demand of the Cope–Osborn theory, and the fact of this co-existence would be a criterion for its correctness. In that event, however, *Morganucodon* could not be regarded as a prepantothere.

For the solution of these problems we require a much more extensive mammalian fauna from the Mesozoic than we at present possess. This need is further emphasized by the existence of the tooth described above.

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Order of Genes in the Fifth Linkage Group of the House Mouse

WORK carried out in this Department during the past two years on the fifth linkage group in *Mus musculus* has established the order circler (*kr*), agouti (*A*), undulated (*un*), wellhaarig (*we*) and pallid (*pa*)[1]. Recent work also suggests that a gene (*pl*) modifying the frequency of manifestation of polydactyly is located in this region, possibly between *A* and *pa*. Mrs. Wallace[2], also working in this Department, determined a linkage of the order of 25 per cent recombination between fidget (*fi*) and Danforth's short tail (*Sd*). About the same time, Carter and Grüneberg[3] ascertained a linkage of about 33·5 per cent recombination between fidget and agouti. Earlier work, both at Cambridge and at the Jackson Memorial Laboratory, Bar Harbor, showed indications of a loose linkage (about 40 per cent recombination) between *A* and *Sd*. Thus there was clear evidence of a second series of loci in the order *A*—*fi*—*Sd*.

The relation between these two series was, however, still in doubt. To determine the order of the loci *A*, *pa* and *Sd*, as one of four projects concerning the fifth chromosome and using stock available in this Department, I set up triple backcrosses of the types

$$Sd\ A\ +/+\ a^t\ pa\ =\ +\ a^t\ pa/+\ a^t\ pa, \qquad (1)$$

and

$$Sd\ a^t\ +/+\ A^y\ pa\ =\ +\ a^t\ pa/+\ a^t\ pa, \qquad (2)$$

the heterozygous parent being male in sixteen of the matings and female in two.

The offspring must fall into four (double) phenotypic classes, for example, in case (1) (genotypes written vertically)

I	II	III	IV
Sd +	+ *Sd*	*Sd* +	*Sd* +
A a^t	*A* a^t	*A* a^t	a^t *A*
+ *pa*	+ *pa*	*pa* +	+ *pa*

Kosambi's theory of recombination[4] (using provisional recombination values, *Sd*—*A* 42 per cent and *A*—*pa* 15 per cent) gives two sets of expected frequencies for these classes, depending on the orders

(*a*) *Sd*—*A*—*pa* or (*b*) *Sd*—*pa*—*A*.

Out of a total of 277 mice bred from both types of mating, the observed and expected class numbers were

	I	II	III	IV
Obs.	135	96	16	30
Exp. *a*	134·9999	100·4501	25·6601	15·8899
Exp. *b*	148·0617	87·3883	12·5983	28·9517

To compare the goodness of fit of the rival hypotheses, χ^2, calculated on three degrees of freedom, comes to

	χ^2_3	P.
Hyp. (*a*)	16·36	< 0·01
Hyp. (*b*)	2·96	0·5–0·3

These observations are therefore in good agreement with the order

Sd—*pa*—*A*,

and in strong disagreement with the alternative order. This makes the order of these seven factors:

kr—*A*—*un*—*we*—*pa*—*fi*—*Sd*.

A fuller account of this work will be published later in *Heredity*.

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Effect of Moisture on the Frictional Properties of Jute Fibre

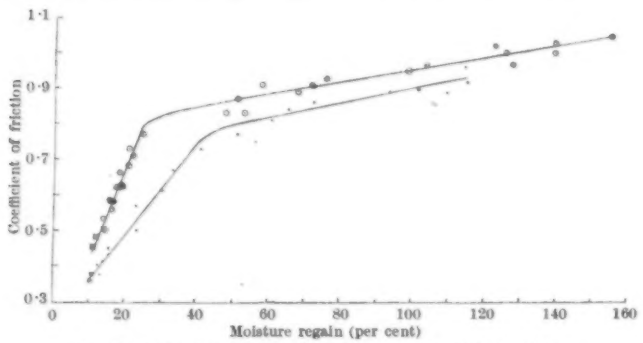
IN connexion with the measurement of frictional characters of jute fibre (a full report of which will be published elsewhere) by allowing a fibre pad on a metal block to slide over another the inclination of which could be increased gradually, the following results on the effect of relative humidity on the coefficient of friction (μ)—fibres sliding parallel to one another—were obtained:

Sample *A*		Sample *B*	
Relat. humidity (per cent)	μ	Relat. humidity (per cent)	μ
78	0·54	80	0·56
58	0·46	62	0·48
46	0·41	43	0·37

The samples were conditioned in desiccators over appropriate solutions for seven days or more, and were tested for friction when the room conditions were at about the corresponding relative humidities. As in the case of other textile materials[1,2], between 40 and 80 per cent relative humidity, the coefficient of friction of jute fibre appears to increase approximately linearly with relative humidity.

In order to see the change beyond the above range of humidities, particularly when jute contains more

moisture than that corresponding to the saturation vapour pressure of water, several jute bundles were soaked in distilled water for 15 min., squeezed and allowed to dry in a slow current of air at about 60 per cent relative humidity. At different intervals of time the bundles were taken one after another and put into stoppered bottles to allow the interior and the surface moisture to reach equilibrium. After one hour (which is not, however, sufficient for equilibrium), each bundle was tested for friction. Immediately after each test, the pads were put inside the bottle for the determination of moisture regain. A correction for the loss of moisture during the experiment was found by measuring the rate of loss by evaporation from the bundle before putting into the oven. The bundle, tested immediately after squeezing, had a regain of more than 100 per cent, depending on the pressure applied, while that dried in an air current for four hours had a regain of about 14 per cent. The readings for the individual bundles of two varieties of jute have been plotted in the accompanying graph. The curves are for desorption.



○—○, Tossa jute; ·— ·—, white jute; x—x—, without soaking

The interesting features of the curves are that: (1) each of them shows two distinct linear regions at low and high regains, with a short curved region intervening, between 25 and 40 per cent regain in one case and 35 and 50 per cent in another, indicating a change of behaviour of the fibre surface as it passes from one region to the other; and (2) at lower regains, the friction is rather sensitive to moisture, though not equally for both the fibres, whereas above 50 per cent regain the effect is less pronounced, being practically the same for both.

A probable explanation seems to be that the water molecules adsorbed on the fibre surface (but not in the interior) form a bond between the pads, and as the number of such bonds increases, friction correspondingly increases; after a certain stage, when a multilayer film has been formed, the proportion of water molecules contributing to the surface bonding falls and the slope of the curve diminishes.

This may throw some light on the mechanism of moisture adsorption on the fibre surface at different moisture conditions. Further work on these lines is in progress.

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A New Cholinesterase in Swine Serum

There are at present two groups of enzymes in mammals which hydrolyse acetylcholine: the first hydrolyses acetylcholine and acetyl-β-methylcholine and is found primarily in nervous tissue and red blood cells; the second group hydrolyses acetylcholine and benzoylcholine and is found in the serum and tissues of some animal species. Characteristic of this last group is the enzyme in human serum. In addition, there is one other related enzyme or group of enzymes which hydrolyses benzoylcholine but not acetylcholine. This was first noted and labelled benzoylcholinesterase by Sawyer[1], and was reported by us as occurring in rabbit serum[2].

We are now reporting a new enzyme which hydrolyses acetylcholine, but neither benzoylcholine nor acetyl-β-methylcholine to any significant degree. This enzyme was observed in swine serum, and was found to yield 160 to 260 microlitres carbon dioxide per c.c. in eight pigs studied. The methods of determination are identical with those described by us in a recent paper[3].

Pontocaine inhibition has been used in the classification of these enzymes. Swine serum cholinesterase activity is inhibited completely by 10^{-4} *M* pontocaine, and in this respect is similar to the cholinesterase of human serum. However, the human serum enzyme hydrolyses acetylcholine and benzoylcholine in a constant ratio, and since the swine serum does not hydrolyse benzoylcholine, it must be considered a separate enzyme.

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Alkaline Hydrolysis of Trichothecin

The preparation, and biological and preliminary chemical properties of trichothecin, an antifungal substance from *Trichothecium roseum* Link, have been described[1]. From the data then available it was erroneously concluded that the compound was a lactone with the probable molecular formula $C_{15}H_{20}O_4$. Further work has shown that trichothecin is an ester, $C_{19}H_{24}O_5$, the components of which are *iso*crotonic acid and a ketonic alcohol, trichothecolone.

The antifungal compound gave on analysis (Weiler and Strauss) C = 68·9, 68·5, 68·7, 68·8, 68·9; H = 7·2, 7·2, 7·3, 7·4, 7·5 per cent; mol. wt. (Rast) = 332, 312, 320; $C_{19}H_{24}O_5$ requires: C = 68·6; H = 7·3 per cent; mol. wt. = 332. Trichothecin 2 : 4-dinitrophenylhydrazone (m.p. 203°) gives C = 58·6, 58·7; H = 5·2, 5·2; N = 10·5, 10·8 per cent; $C_{25}H_{28}O_8N_4$ requires: C = 58·6; H = 5·5; N =

10·9 per cent. Trichothecin forms an addition compound on treatment with concentrated aqueous hydrochloric acid (m.p. 132·5°); found: C = 61·8; H = 6·8; Cl = 9·4 per cent; $C_{19}H_{25}O_6Cl$ requires C = 61·8; H = 6·8; Cl = 9·6 per cent.

Hydrolysis in the cold with a methanolic solution of potassium hydroxide gave the ketonic alcohol, trichothecolone (m.p. 182°), which was extracted from the alkaline solution with chloroform (found: C = 68·8, 68·9; H = 7·3, 7·3; (C)CH_3 = 10·0, 10·6 per cent; mol. wt. (Rast) = 244, 248. $C_{15}H_{20}O_4$ requires: C = 68·2; H = 7·5; two (C)CH_3 groups = 11·4 per cent; mol. wt. = 264). Acidification of the aqueous liquor and extraction with chloroform gave a colourless, liquid acid (b.p. 210°); found: C = 51·4, 51·6; H = 8·4, 8·8; methoxyl = 21·8; active hydrogen = 0·86 per cent; acid equivalent = 116. $CH_3O.C_3H_6COOH$ requires: C = 50·9; H = 8·6; methoxyl = 26·3; active hydrogen = 0·85 per cent; acid equivalent = 118. The *p*-phenylphenacyl ester (m.p. 60°) was prepared; found: C = 72·5, 72·4; H = 6·3, 6·4 per cent. $C_{19}H_{20}O_4$ requires: C = 73·0; H = 6·5 per cent. Since the methoxyl group is absent in trichothecin, it appeared likely that addition of methyl alcohol had taken place, during hydrolysis, probably at a reactive double bond. Purdie and Marshall[2] showed that ethyl crotonate on treatment with sodium methoxide gave sodium β-methoxy-*n*-butyrate. We have submitted ethyl crotonate to hydrolysis under the conditions used for hydrolysis of trichothecin. The acidic product (b.p. 210°, acid equivalent 114) was identical with the acid obtained on hydrolysis of trichothecin. This acid formed a methyl ester (b.p. 144–148°) and an amide (colourless scaly crystals, m.p. 68°) and it was concluded that the acid is β-methoxy-*n*-butyric acid.

The trichothecin molecule contains two ethylenic groups, and the ultra-violet absorption spectrum indicates that one of these is conjugated with a carbonyl group[1b]. Reduction with hydrogen at atmospheric pressure in the presence of palladized charcoal gave tetrahydrotrichothecin, a colourless syrup, which gave by Allen's method a 2 : 4-dinitrophenylhydrazone, $C_{21}H_{26}O_7N_4$ (m.p. 112–113°). Hydrolysis of tetrahydrotrichothecin, under the conditions described above, gave *n*-butyric acid and dihydrotrichothecolone, $C_{15}H_{22}O_4$. The acid gave a *p*-phenylphenacyl ester (m.p. 81°), found: C = 76·8; H = 6·3 per cent; $C_{19}H_{18}O_3$ requires C = 76·6; H = 6·4 per cent. The mixed melting point with authentic *p*-phenylphenacyl-*n*-butyrate (m.p. 82°) was undepressed.

Hydrolysis of trichothecin by heating its methanol solution with an equal volume of a saturated aqueous solution of barium hydroxide gave β-methoxy-*n*-butyric acid and *iso*trichothecolone, $C_{15}H_{20}O_4$.

Trichothecin dissolved rapidly on vigorous boiling with an excess of 0·5 *N* aqueous sodium hydroxide. Extraction of the reaction product in the usual manner gave *iso*trichothecolone and a liquid acid, which reduced ammoniacal silver nitrate; the crude acid had an acid equivalent of 90. It gave a *p*-phenylphenacyl ester (m.p. 102–3°); found: C = 76·8, 77·2; H = 5·8, 5·7 per cent; $C_{19}H_{16}O_3$ requires: C = 77·1; H = 5·7 per cent. *Iso*crotonic acid was prepared by the method of Michael and Schulthess[3]. The melting point of *p*-phenylphenacyl *iso*crotonate (m.p. 102–3°) was undepressed on admixture with the above ester, while that of *p*-phenylphenacyl crotonate (m.p. 106°) was depressed to 92°.

Acetaldehyde was isolated as the 2 : 4-dinitrophenylhydrazone on ozonolysis of trichothecin, which is in agreement with the presence of a propenyl group in the *iso*crotonic acid component.

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J. E. Gill

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Nobel Division,
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June 15.

[1] Freeman, G. G., and Morrison, R. I., (a) *Nature*, **162**, 30 (1948); (b) *Biochem. J.*, **44**, 1 (1949); (c) *J. Gen. Microbiol.*, **3**, 60 (1949).
[2] Purdie, T., and Marshall, W., *J. Chem. Soc.*, **59**, 476 (1891).
[3] Michael, A., and Schulthess, J., *J. prakt. Chem.* (2), **46**, 236 (1892).

Histochemical Demonstration of Lipase

The lipase method of Gomori[1] has been little used in morbid histology. This communication is concerned with the results of a preliminary study of the distribution of lipase in human tissue using Gomori's method. The method, which is one of his ingenious techniques using the deposition of an insoluble calcium salt at the site of enzyme activity, is based on the splitting of a water-soluble ester of higher fatty acids and conversion of the calcium soap to lead sulphide. The original method[1] and the modification of Wachstein[2] were satisfactory, using as substrate Tween 40 or 60 as recommended by them, or Crill 6 or 7, which is a similar British product (Croda, Ltd., Goole, Yorks).

The results obtained were variable, depending on a number of factors such as postmortem change, length of fixation in acetone, lengthy heating during paraffin embedding, floating sections on water instead of 70 per cent acetone, overheating of slides to ensure adherence of sections and using material blocked for some months. It would appear that the lability of the enzyme accounts for the various factors producing negative results. It has been suggested by Mark[3] that frozen sections of formalin-fixed tissue may be better than paraffin sections.

In carrying out the two methods used, it was noticed that the *p*H of the substrate mixture tended to fall, and must be maintained close to 7·4 during incubation. Adjusting the *p*H without using a buffer was not satisfactory. If the mounted sections are overheated, the lead sulphide may dissolve. Cobalt replacement was not successful. Heat or treatment with Lugol's iodine was used to inactivate the enzyme in control slides.

The results obtained confirm most of Gomori's findings[4]. The hepatic cells of the liver and the acinar cells of the pancreas were strongly positive, as were desquamated macrophages in lung alveoli. There was patchy activity in fat and bronchial epithelium, and weak activity in the interstitial cells of the testis. Faint staining of red cells, cartilage and keratin was probably due to the adsorption of lead, as they were also faintly positive in the control slides. Negative results were obtained with other organs, including lymph nodes, bone marrow, lactating breast, kidney and two pancreatic carcinomas.

Despite theoretical objections to enzyme methods[5], they may become valuable diagnostic tools in the future. It is surprising that the pancreatic carcinomas were negative. This may be due to the fact that the tumours arose from duct epithelium or to the fact that neoplasia has abolished cell function. The reaction of the liver may be due in part to esterases.

The lipase in some macrophages suggested the trial of macrophages in tissue culture; Dr. Charity Waymouth kindly gave me some tissue cultures of chick heart and Rous sarcoma No. 1. The macrophages of the former were slightly positive, of the latter negative although they contained fat globules. Probably the resting macrophage contains little lipase, but when actively phagocytic may elaborate a good deal.

Both Gomori's and Wachstein's histochemical methods for demonstrating lipase in tissue cells require further improvement before they can be relied upon to give consistent results and, therefore, to be of value in diagnostic work.

P. H. A. Sneath

Department of Morbid Anatomy,
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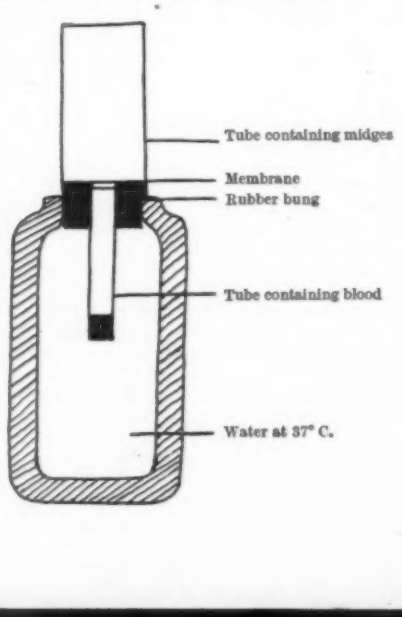
June 13.

[1] Gomori, G., *Proc. Soc. Exp. Biol. N.Y.*, **58**, 362 (1945).
[2] Wachstein, *J. Exp. Med.*, **84**, 25 (1946).
[3] Mark, *Arch. Path.*, **49**, 545 (1950).
[4] Gomori, G., *Arch. Path.*, **41**, 121 (1946).
[5] Danielli, J. F., *Nature*, **165**, 762 (1950).

Artificial Feeding of *Culicoides nubeculosus* in the Laboratory

Although the normal hosts of *Culicoides nubeculosus* are horses and cattle, they will readily bite man in the laboratory, and a strain has been maintained in this way; but as the numbers increased it became essential to devise a method by which they might be fed artificially. At 20° C., the temperature at which the strain is kept, the females will take their first blood meal three days after emergence, will oviposit two to three days later and require a further blood meal before they will oviposit again. The duration of the life-cycle is four to five weeks.

The method was based on that used by Bishop and Gilchrist[1] for the feeding of *Aedes ægypti*. Unlike *A. ægypti*, *C. nubeculosus* in a large container will not readily seek its food, nor can it be induced to feed through gauze. The midges were therefore enclosed in a small tube and could be in direct contact with the membrane. The apparatus is shown in the diagram. A vacuum flask served as a constant temperature bath and was filled with water at 37° C. The membranes were made from pieces of chicken skin which were soaked in absolute alcohol for thirty minutes and washed; these could be dried for storage and became flexible again when soaked in water. Midges were withdrawn from the breeding cages into 4 in. × 1 in. tubes which were inverted over the membrane. It was found that unless the membrane was distended by blood under slight pressure, the proboscis of the insect was so short that air bubbles tended to form immediately below the membrane; the necessary pressure was obtained by filling the tube completely before closing with the rubber bung and laying the whole apparatus on its side during the experiment.



Bishop and Gilchrist have already commented on the relative merits of whole blood, defibrinated blood and plasma, and also of heparinated and citrated blood. In the present experiments, results were obtained only on the comparative merits of the human subject, heparinated ox blood and citrated ox blood. Ox blood was withdrawn from the veins and was sufficiently sterile to be stored at 4° C. for twelve days. To allow for storage, heparin was used at a dilution of 1/1,000.

All the midges used were three to four days old and of the same generation in each experiment. The total number was divided into three, one-third being offered a human subject, one-third heparinated blood and one-third citrated blood.

Relative Merits of Human Blood, Heparinated and Citrated Ox Blood for the Feeding of *C. nubeculosus*

No. of females offered food	No. which fed	No. which oviposited	Average No. eggs laid	Length of life	
84	71 (72·6%)	48 (67·6%)	380	4–7 days	Human subject
77	56 (70·1%)	38 (67·8%)	371	4–7 days	Heparinated ox blood
61	20 (32·8%)	10 (50%)	247	3–5 days	Citrated ox blood

From the results shown in the accompanying table, it will be seen that only 32·8 per cent of the midges offered citrated blood fed, whereas 70·1 and 72·6 per cent fed on heparinated blood and the human subject respectively. On several occasions 100 per cent of the females have fed when offered both heparinated and human blood.

Only 50 per cent of the females which fed on citrated blood afterwards oviposited; but 67·8 and 67·6 per cent oviposited of those fed on heparinated and human blood. The average number of eggs laid by the group fed on citrated blood was considerably less than that laid by the other two groups, and the average length of life of the females was also less. Consequently, citrated blood was regarded as being unsuitable, and it seems that heparinated blood is an adequate substitute for the human subject.

Enid W. Roberts

Department of Zoology,
University,
Glasgow, W.2.
June 21.

[1] Bishop, Ann, and Gilchrist, B., *Parasit.*, **37**, 85 (1946).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 23

SOCIETY OF DAIRY TECHNOLOGY (at the Conway Hall, Red Lion Square, London, W.C.1), at 10.30 a.m.—Annual General Meeting; at 2.30 p.m.—Dr. J. G. Davis and Dr. T. Ashton: "Laboratory Control of Processing and Manufacture".

ROYAL METEOROLOGICAL SOCIETY, SCOTTISH CENTRE (in the Department of Natural Philosophy, The University, Drummond Street, Edinburgh), at 5.15 p.m.—Display of meteorological films, including "Seeding the Clouds", by Mr. V. J. Schaefer.

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Room, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—"The Scientific Work of Descartes" (Dr. J. F. Scott: "Descartes' Contributions to Physics"; Dr. A. C. Crombie: "Descartes' Contributions to Biology and Scientific Method").

INSTITUTION OF THE RUBBER INDUSTRY, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 6.15 p.m.—Mr. E. Morris: "Engineering in the Rubber Industry".

Tuesday, October 24

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. G. P. Wells: "The Behaviour of Worms".* (Further Lecture on October 31.)

CHADWICK PUBLIC LECTURE (in the Meyerstein Lecture Theatre, Westminster Medical School, 17 Horseferry Road, London, S.W.1), at 4.30 p.m.—Dr. Neville M. Goodman: "Public Health Administration in Western Union Countries—a Comparative Synthesis".*

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Mlle. Jeanne A. L. Cuisinier: "The Sacred Dance in Indo-China and Indonesia".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. H. Hartridge, F.R.S.: "Some Recent Advances in the Physiology of Vision".* (Further Lectures on October 31 and November 7.)

ROYAL SOCIETY OF MEDICINE, MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Discussion on "Medical Education" (to be opened by Dr. L. Birley).

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. J. H. Chesters: "Flow Patterns in Furnaces".

TEXTILE INSTITUTE (at St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. C. S. Newton: "Carpets and their Manufacture" (Technicolor sound film, followed by discussion).

TEXTILE INSTITUTE, YORKSHIRE SECTION (at the University, Leeds), at 7.15 p.m.—Mr. L. G. Humble: "Work Study".

Wednesday, October 25

INSTITUTE OF PHYSICS, EDUCATION GROUP (in the Fyvie Hall, The Polytechnic, Regent Street, London, W.1), at 3 p.m.—Lord Eustace Percy: "Technical Universities".

CHEMICAL SOCIETY, GLASGOW SECTION (joint meeting with the ALCHEMISTS CLUB and the ANDERSONIAN CHEMICAL SOCIETY, at the Royal Technical College, Glasgow), at 3.30 p.m.—Prof. R. P. Linstead, F.R.S.: "Recent Developments in Macrocyclic Pigments".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. Dr. H. A. Brouwer (Amsterdam): "Movements of Island Arcs" (Sixth William Smith Lecture).

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Mr. E. W. Ayers and Mr. J. Y. Morton: "The Subjective Calibration of Bone-Conduction Receivers for Hearing Aids".

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at the Royal Institution, Albemarle Street, London, W.1), at 5.15 p.m.—Sir Lawrence Bragg, F.R.S.: "Science and the Adventure of Living" (Radford Mather Lecture).

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, CHEMICAL SECTION (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—"Stainless Steel" (Technicolor films prepared by the staff of Firth Vickers and Co., Ltd.).

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. C. F. Powell, F.R.S.: "Cosmic Radiation".* (Further Lectures on October 26 and 27.)

UNIVERSITY OF LONDON (in the Department of Electrical Engineering, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. A. H. W. Beck: "Ultra High Frequency Valves".* (Further Lectures on November 1, 8, 15, 22, 29 and December 6.)

SOCIETY OF CHEMICAL INDUSTRY, NUTRITION PANEL OF THE FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—"Factors in Distribution affecting the Quality and Nutritional Value of Foodstuffs. 1, Fish and Meat" (Speakers: Dr. G. A. Reay, Dr. E. H. Callow and Dr. Magnus A. Pyke).

MANCHESTER METALLURGICAL SOCIETY (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Mr. R. S. Jackson: "Review of Current Research on Springs and Spring Steels".

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Waldorf Hotel, Aldwych, London, W.C.2), at 6.30 p.m.—Dr. V. E. Yarsley: "The Limitations of Plastics".

BRITISH ASSOCIATION OF CHEMISTS (at the Wellcome Research Institution, 183 Euston Road, London, N.W.1), at 7 p.m.—Mr. C. E. Hollis: "Research Aspects of Polyvinyl Chloride Plastics". (Members of the Plastics and Polymer Group of the Society of Chemical Industry are invited.)

INSTITUTION OF WORKS MANAGERS (at the Waldorf Hotel, Aldwych, London, W.C.2).—Annual General Meeting.

Thursday, October 26

TEXTILE INSTITUTE (at the Mechanics' Institute, Burnley), at 10 a.m.—Conference on "Yarn Preparation".

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 3 p.m.—Scientific Papers.

EAST MALLING RESEARCH STATION (at Withersdane, Wye College, Wye, Ashford, Kent), at 4 p.m.—Sir Edward Salisbury, F.R.S.: "The Fruit Tree and its Environment".

LINNEAN SOCIETY (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. F. J. Manning: "Recent and Fossil Honey Bees—Some Aspects of their Psychology, Phylogeny and Evolution"; Prof. J. McLean Thompson: "On the Cannon Ball Tree (*Couroupita guianensis* Aubl.)".

ROYAL INSTITUTE OF CHEMISTRY, MANCHESTER AND DISTRICT SECTION (in the Chemistry Lecture Theatre, The University, Manchester), at 6.30 p.m.—Sir Charles Goodeve, F.R.S.: "The Physical Chemistry of Iron and Steel" (Sixth Dalton Lecture).

CHEMICAL SOCIETY, EDINBURGH SECTION (joint meeting with the ROYAL INSTITUTE OF CHEMISTRY and the SOCIETY OF CHEMICAL INDUSTRY, at the North British Station Hotel, Edinburgh), at 7.30 p.m.—Dr. A. E. Werner: "The Scientific Examination of Pictures".

ROYAL AERONAUTICAL SOCIETY, GRADUATE AND STUDENT SECTION (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Mr. J. A. Dunsby: "The Aerodynamics of Compressor and Turbine Cascades".

ASSOCIATION OF SCIENTIFIC WORKERS (in Committee Room No. 4, Church House, Westminster, London, S.W.1), at 7.45 p.m.—Prof. T'u Chang-wang and Prof. Chou Pei-yuan: "Science in China To-day".*

PHARMACEUTICAL SOCIETY, MANCHESTER, SALFORD AND DISTRICT BRANCH (in the Council Chamber, Houldsworth Hall, Manchester), at 7.45 p.m.—Mr. B. J. Thomas: "Modern Developments in Pharmaceutics".

Friday, October 27

ASLIB, NORTHERN BRANCH (in the Lecture Room, Central Library, St. Peter's Square, Manchester), at 11.30 a.m.—Annual General Meeting; at 2.15 p.m.—Mr. W. H. Glasscock and Mr. Horrocks: "Government and Official Publications".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Discussion on "Form Grinding by Mechanical and Optical Methods" (to be opened by Mr. E. A. Cooke).

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL GROUP (at the Albert Hall, Peter Street, Manchester), at 6.45 p.m.—Mr. A. W. Swan: "An Operational Research Project based on Time Study Data".

TELEVISION SOCIETY (at the Cinema Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Dr. Leonard Levy and Mr. D. W. West: "Modern Phosphors for Television C.R. Tubes".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

AGRICULTURAL ENTOMOLOGIST—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (October 28).

JUNIOR ASSISTANT PHYSICIST—The Secretary, Mount Vernon Hospital and the Radium Institute, Northwood, Middx. (October 28).

LECTURER IN CHEMISTRY at Coventry Technical College—The Director of Education, Council House, Coventry (October 28).

LECTURER IN CHEMISTRY, and a LECTURER IN MATHEMATICS AND PHYSICS—The Director, Robert Gordon's Technical College, Aberdeen (October 28).

LECTURER IN THE DEPARTMENT OF PHYSICS AND TELECOMMUNICATIONS—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (October 28).

DISTRICT ENGINEERS (Ref. E.129/50A), a MUNICIPAL ENGINEER (Ref. E.129/50A), and a ROAD ENGINEER (Ref. E.130/50A), in the Public Works Department under the Government of Cyrenaica—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (October 30).

ANALYTICAL CHEMIST—The Director, Brewing Industry Research Foundation, 40 Sackville Street, London, W.1 (October 31).

ASSISTANT IN STATISTICAL RESEARCH—The Secretary, Faculty of Economics and Politics, The Marshall Library, Downing Street, Cambridge (October 31).

CLINICAL PHYSICIST to assist with the routine and research work in connexion with the Department of Radiotherapy—The House Governor and Secretary, Royal Cancer Hospital, Fulham Road, London, S.W.3 (October 31).

METEOROLOGICAL OFFICERS (6, with honours university degree covering physics, mathematical physics or mathematics, or civil, mechanical or electrical engineering, or a university degree in meteorology) in the Department of Industry and Commerce—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (October 31).

MICRO-ANALYTICAL ASSISTANT—The Technical Superintendent, Brewing Industry Research Foundation, Nutfield, Surrey (October 31).

PHYSICIST to assist in work with radioactive isotopes—The House Governor and Secretary, Royal Cancer Hospital, Fulham Road, London, S.W.3 (October 31).

LECTURER (Grade I) IN CIVIL ENGINEERING—The Secretary, The University, Birmingham 3 (November 1).

HORTICULTURIST, and an ASSISTANT MYCOLOGIST, to the States of Jersey—The Secretary, Committee of Agriculture, Jersey (November 4).

RESEARCH CHEMIST (Scientist, Grade III) at the Central Research Establishment at Stoke Orchard, near Cheltenham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/262 (November 4).

RESEARCH FELLOWSHIP IN CHEMISTRY—The Secretary, The University, Aberdeen (November 6).

TECHNICAL ASSISTANT (male with a University degree in engineering or science or equivalent qualifications, together with knowledge of, and practical experience in, control of work in geodesy applied to mapping and aerial navigation, map construction and cartography, process photography and lithographic reproduction), to the Head of Establishment at the Air Ministry Survey production centre at Teddington—The Secretary, Civil Service Commission, Scientific Branch, London, W.1, quoting No. 3310 (November 9).

ASSISTANT LECTURER IN ECONOMICS—The Registrar, The University, Manchester (November 10).

RESEARCH ASSISTANT IN ECONOMICS or ECONOMIC STATISTICS—The Registrar, The University, Manchester (November 10)

SENIOR LECTURER IN BACTERIOLOGY in the Department of Pathology—The Secretary, Institute of Ophthalmology, Judd Street, London, W.C.1 (November 10).

CHIEF ENGINEER, and a CHIEF POLLUTION AND FISHERIES OFFICER—The Clerk of the Wear and Tees River Board, Clark's Yard, High Row, Darlington, Co. Durham (November 11).

LECTURER or ASSISTANT LECTURER in the Fluid Motion Laboratory—The Registrar, The University, Manchester 13 (November 11).

CHEMIST AND BACTERIOLOGIST—The Engineer and Manager, Water Department, Town Hall, Reading, endorsed 'Chemist and Bacteriologist' (November 13).

SENIOR EXPERIMENTAL OFFICERS and EXPERIMENTAL OFFICERS at Admiralty Experimental Establishments in various parts of Great Britain: MECHANICAL ENGINEERS (Ref. C.267/50) with research and development experience in light mechanisms, ELECTRICAL ENGINEERS (Ref. D.152/50), or PHYSICISTS (Ref. A.146/50) with research and development experience in light electrical mechanisms, electronics or acoustics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (November 13).

CHAIR OF CIVIL ENGINEERING at Auckland University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 15).

LECTURER IN BIOCHEMISTRY (with special qualifications in biochemistry or organic chemistry and, preferably, experience in dairy chemistry or chemistry of foods)—The Registrar, Massey Agricultural College, Palmerston North, New Zealand (November 15).

LECTURER IN THE DEPARTMENT OF GEOGRAPHY, University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 15).

LECTURER IN MECHANICAL ENGINEERING at Auckland University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 15).

SENIOR LECTURER and a LECTURER IN PSYCHOLOGY at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 15).

SENIOR TOBACCO EXTENSION OFFICER (with a degree in agriculture at an approved university normally involving a four-year course) in the Department of Agriculture and Lands, Southern Rhodesia—The Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (November 15).

DEPUTY CHIEF SCIENTIFIC OFFICER at a Research and Development Establishment near London, to take charge of all the engineering groups in the Establishment—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3324 (November 16).

CHAIR OF PHARMACOLOGY—The Registrar, The University, Liverpool (November 18).

HEAD OF THE DEPARTMENT OF MATHEMATICS, Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 18).

AGRICULTURAL ECONOMIST in the Ministry of Agriculture and Fisheries, and ASSISTANT AGRICULTURAL ECONOMISTS (3 in the Ministry of Agriculture and Fisheries and 3 in the Department of Agriculture for Scotland)—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 3326 (November 24).

BRUNNER CHAIR OF ECONOMIC SCIENCE—The Registrar, The University, Liverpool (November 25).

SENIOR LECTURER IN BOTANY at Canterbury University, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 27).

ASSISTANT LECTURER or LECTURER IN BOTANY at Gordon Memorial College, Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 30).

ASSISTANT LECTURER or LECTURER IN MECHANICAL ENGINEERING at Gordon Memorial College, Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 30).

CHAIR OF AGRICULTURE at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 30).

MECHANICAL ENGINEER in the State Hydro-electric Department, New Zealand—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (November 30).

PROFESSOR OF AGRICULTURAL CHEMISTRY—The Secretary and Registrar, University College of North Wales, Bangor (November 30).

PROFESSOR OF CIVIL ENGINEERING, and a PROFESSOR OF PHYSICS, at Gordon Memorial College, Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 30).

RESEARCH ASSISTANT IN RADIOCHEMISTRY—The Secretary, The University, 38 North Bailey, Durham (November 30).

SENIOR LECTURER or LECTURER IN BOTANY at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 30).

ASSISTANT ELECTRICAL ENGINEER in the Railway Department, Gold Coast—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27326/40.

ASSISTANT EXPERIMENTAL OFFICER IN THE DEPARTMENT OF CHEMISTRY, for duties requiring a capacity to carry out mathematical computations—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, Berks.

ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments, divided between (*a*) mathematical and physical sciences, (*b*) chemistry and metallurgy, (*c*) engineering subjects and (*d*) miscellaneous (including, e.g., library and technical information services)—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3068.

ASSISTANT LECTURER AND DEMONSTRATOR IN THE CHEMISTRY DEPARTMENT—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

CHEMISTS, PHYSICISTS and METALLURGISTS (men and women) as Senior Experimental Officers or Experimental Officers in the Research, and Test and Inspection Branches of the Post Office Engineering Department—The Engineer-in-Chief, Staff Branch (St. 1), Alder House, Aldersgate Street, London, E.C.1.

DEVELOPMENT ASSISTANTS AT THE ADMIRALTY ENGINEERING LABORATORY, West Drayton, for experimental and development work in connexion with electrical equipment of warships—The Admiralty, C.E.II, Room 88, Empire Hotel, Bath.

ENGINEERING ASSISTANT by the Government of Northern Rhodesia—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.24886/3A.

GEORGE HOLT FELLOWSHIP IN PHYSIOLOGY—The Registrar, The University, Liverpool.

GOVERNMENT ANALYST in Barbados—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27106/44/50.

INSPECTORS OF MINES, Nigeria—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27099/13.

LECTURER IN BOTANY (with particular interest in plant physiology) for classes to B.Sc. (special) Degree standard—The Clerk, Northern Polytechnic, Holloway, London, N.7.

NUTRITION OFFICER (woman) in H.M. Colonial Service, Nigeria, to investigate and advise upon nutrition problems—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27321/4.

PETROLOGIST, or a PHYSICAL CHEMIST with a knowledge of petrology—The Director of Research, British Ceramic Research Association, Queens Road, Penkhull, Stoke-on-Trent.

PHYSICAL CHEMIST (with a good degree in physical chemistry) to carry out research on high temperature physico-chemical processes of interest in iron and steel making—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

PHYSICIST (with honours degree in physics and hospital experience of radium and X-radiation) IN THE RADIOTHERAPY DEPARTMENT of the Kent and Canterbury Hospital—The Secretary, Canterbury Group Hospital Management Committee, St. Martin's Hospital, Canterbury.

PROFESSIONAL ENGINEERS in many departments of the Civil Service for a wide variety of engineering duties—The Secretary, Civil Service Commission, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3225.

RESEARCH ASSISTANT (Biological) (with degree in subjects including physiology or zoology)—The Professor of Chemical Pathology, Westminster Medical School, 17 Horseferry Road, London, S.W.1.

RESEARCH CHEMIST in connexion with the study of problems of fruit and vegetable preservation—The Director, Research Station (University of Bristol), Campden, Glos.

RESEARCH CHEMISTS—The Secretary, British Food Manufacturing Industries Research Association, Randalls Road, Leatherhead, Surrey.

RESEARCH FELLOWS IN CLIMATOLOGY (open especially to graduates in botany and agronomy) and PHYSIOGRAPHY (open to graduates in geology, soils and geography)—The Director, Ontario Research Foundation, 43 Queen's Park, Toronto 5, Canada.

RESEARCH MANAGER to take charge of a group of laboratories engaged on applied research work in connexion with a wide range of new chemical processes associated with atomic energy development, ASSISTANT RESEARCH MANAGERS to be responsible to the Research Manager for leading teams engaged on the applied research work outlined above, an ASSISTANT DEVELOPMENT MANAGER to be responsible to the Development Manager for leading teams engaged on semi-scale and pilot plant experimental work in connexion with the development of new chemical processes, and RESEARCH CHEMISTS or PHYSICISTS to undertake chemical and radio-chemical research work associated with atomic energy development, at Windscale Works, Sellafield, Cumberland—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

RESEARCH PHYSICIST for work in South Wales on bio-physical factors concerned in clinical radiography—The Director, Pneumoconiosis Research Unit, Llandough Hospital, Cardiff.

SANITATION ENGINEER in the Works and Hydraulics Department, Trinidad—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27322/130.

SENIOR LECTURER IN PHYSIOLOGY—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1.

WATER ENGINEER in the Public Works Department, St. Kitts-Nevis—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27329/37/50.